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The Month.

The Engineering and Machinery Exhibition at Olympia.—The Engineering and Machinery Exhibition has provided the average Londoner with an opportunity of familiarising himself with some of the less obvious achievements of modern engineering. It is true that he travels by motor omnibus and tube, and that when he goes on a holiday he may travel behind one of these triumphs of British locomotive engineering, or may cross the channel in a turbine steamer, but these he takes as a matter of course, either as part of the legitimate tribute which civilisation pays towards his comfort, or as the dispensation of an all-wise Providence. When the unexpected happens and the human factor or unexpected conditions upset the most careful calculations of the trained engineer, he discourses learnedly on the super-elevation of the outer rail, and the riveting of the bulkheads, or the operation of the watertight doors, aided no doubt by the "expert" opinions which appear in the columns of the daily newspapers.

On these grounds, if on no other, we welcome the holding of an engineering exhibition in London, for while locomotives and steam turbines are practically unrepresented, the triumphs of the art of the machine maker, without whom these locomotives and turbines would

not be possible, is unusually well represented, while here and there one finds steam and gas engines, to say nothing of business systems, and the no less important technical journal.

The *pièce de résistance* of the exhibition is undoubtedly the 18 in. lathe, exhibited by Messrs. Sir W. G. Armstrong, Whitworth & Co. This lathe, which will take work 10 ft. between centres, is driven by a 60 h.-p. direct-current motor, and is capable of taking a cut 1¼ in. deep by ¼ in. traverse at 30 ft. per minute, while the speed control is such that cutting speeds from 30 to 400 ft. per minute may be obtained. This machine can remove one ton of metal per hour.

A no less interesting lathe is exhibited by Messrs. John Stirk & Co. at stand No. 16, where a 10 in. high speed lathe is shown, which, together with the 6 in. slotter, represents the high-water mark in the design of self-contained electrically driven tools, for the electric motor is not attached as if it were an afterthought, but is an integral part of the machine framework; moreover the placing of the electric motor under the headstock of the latter adds to the stability and compactness of the tool.

It would be difficult within the limits of this space to specify even a fraction of the excellent machine tools shown by the various exhibitors. Grinding and gear cutting machines, both of which are becoming more important in manufacturing, are exhibited by Messrs. Schuchardt and Schutte, Charles Churchill & Co., Selig, Sonnenthal & Co., and others, while Bateman's Machine Tool Co. show a planing machine, which may be arranged to have cutting speeds of 20 to 80 ft. per minute, and a return speed of 210 ft. per minute. This planer, unlike the large Vickers-Maxim planer at the electrical exhibition at Olympia last year, has a constant speed electric motor, the quick return speed being obtained mechanically; the extra power required during the reversal and acceleration of the table being supplied by heavy flywheels at each side of the machine. The table, moreover, is brought to rest by means of powerful springs, so that even at the high speeds just mentioned the heavily loaded table may be brought to rest without shock or jar. Messrs. W. H. Allen & Co., Easton and Bessemer and Reavell & Co., display examples of the high-speed engines for which they are justly famed, and the Stirling Boiler Co., Messrs. Cochran & Co., and the Davis Water Tube Boiler are represented, while superheaters are shown by Messrs. MacPhail and Simpson and the Stirling Boiler Co.

The gas engine and the suction gas producer are by no means neglected, and several compact producers are shown.

With the growth of superheating has come a variety of packing and jointing material more or less suited to the new conditions, and these are also well represented. Graphitic lubricants are also a development of recent years, and the material and appliances for feeding it are shown by several firms. Roller and ball bearings are to be seen on several stands, though no very striking innovations are noticeable.

We have said enough to show that the engineer may learn much from a visit to the various stands, and while he may leave feeling that he has seen and heard more than his memory can adequately deal with, we will endeavour to provide him with a suitable refresher in the shape of a comprehensive illustrated *résumé* of the salient features of the show in our next issue.

The Grantham Railway Disaster.—Although the serious wreck of the Scotch express which took place just beyond the Grantham railway station was immediately the work of forces applied similarly to those that caused the recent accident to the American boat train at Salisbury, the attendant circumstances are very different. At Salisbury there is a curve on the main line which the driver attempted to negotiate at too high a speed, either purposely or as the result of oversight. At Grantham, the curve where the wreck took place is situated on the Nottingham branch line, and the express was timed to stop at the station, which is to the south of the junction. Hence the danger of sharp curves to fast traffic is only incidentally a feature of the

latest accident. There can be no manner of doubt that the driver of the Great Northern express fully intended to pull up at Grantham in accordance with instructions. The running orders were clear on this point, the signals were against the train, the engine was in perfect condition, the brakes were in proper order, and the driver was one of the most experienced and reliable men in the employ of the company. Assuming the road to be dry, it would be perfectly easy, as stated by Mr. Ivatt at the coroner's inquest, to stop the train, when travelling at the rate of 60 miles an hour, within 400 to 500 yards, but greasiness of the rails might make a difference of from 500 yards to 600 yards. To make clear the bearing of these figures upon the disaster, they should be examined in connection with the distances of various points north of Salter's Ford signal box, one mile south of Grantham station, where the driver of the express was in the habit of shutting off steam and of commencing to apply the brakes. The distances are approximately as follows :—

	Yds.	Yds.	Yds.
Salter's Ford signal box	—	—	—
South signal box	1,160	—	—
Yard signal box (south end of station platform)	1,760	600	—
North end of station platform ...	2,040	880	280
North signal box	2,170	1,010	410
Scene of wreck	2,320	1,160	560

Now we can see on the basis of Mr. Ivatt's figures that in dry weather the application of the brakes might be deferred without absolute risk until the south signal box had been passed by 280 yards, but that in damp weather they would have to be applied at a distance of from 120 to 420 yards south of that point to insure stoppage of the engine at the north end of the station platform. Thus, taking the speed of the train at fifty miles an hour, the driver would apply the brakes about sixty-three seconds in dry weather or thirty-four seconds in damp weather after passing Salter's Ford box, for the least further delay would involve the risk of running past the station. To defer application of the brakes in weather such as that prevailing on the night of the accident until arrival at the south end of the station platform was to make almost certain that the engine must run for a distance of from 620 yards to 920 yards beyond the north end of the platform and so be capable of travelling at a considerable speed when reaching the scene of the disaster 280 yards beyond the station.

Whether the driver departed from the prudent course of commencing to slacken speed at Salter's Ford box in the hope of making up for lost time on the journey, and then lost his reckoning, or whether he forgot all about the brakes until reminded by sight of the station, are points upon which no light can be thrown. The fact is that, although steam appears to have been shut off at Salter's Ford box, the brakes were not applied until too late. So the train rushed through the station, and dashed past the north end signal box at the rate of about forty miles an hour.

Even then no harm would have resulted if the main line had been clear. Unfortunately, however, the branch instead of the main line was open, and the express was diverted to the curve whose radius is such as to render it unsuitable for speeds exceeding 15 miles an hour. As the speed of the express was not far short of 40 miles an hour when entering the curve, serious disaster was inevitable. The coroner's jury very properly came to the conclusion that the points on the main line should be set clear as soon as a train had passed them. The facts bearing upon the working of the junction are that the points had been set to let a train in from Nottingham shortly before the arrival of the express, and they were allowed to remain as so set in readiness for the departure of a train for Nottingham timed to leave Grantham five minutes before the Scotch express. The arrangement looks very reasonable, and the view of the company seems to have been that the contingency of a runaway train was too remote for consideration. But the system makes no provision for safety in the case of failure of the brakes or derangement of the engine, or in case the signals cannot be seen clearly owing to fog. To keep the main line clear for through trains, and for stopping trains until they have actually stopped, is obviously a desirable method of working and one that involves so little trouble that it is to be regretted its necessity has not been generally recognised by railway companies.

The *Mauretania*.—A fundamental condition of the agreement between the Admiralty and the Cunard Company with regard to the *Lusitania* and *Mauretania* is that these vessels shall be capable of maintaining a minimum average ocean speed of from 24 to 25 knots in moderate weather. The fulfilment of this condition will restore to Great Britain the premier position in speed on the Transatlantic route which was taken by Germany a few years back. The *Mauretania* and her sister ship mark, not only a notable advance in naval architecture but further progress in the development of the steam turbine. The first of these points is made strikingly manifest by

comparing the new Cunarders with the *Kaiser Wilhelm II.*, the largest and fastest German liner afloat. In respect of size, the *Mauretania* and *Lusitania* measure 790 ft. long, 88 ft. beam, and 60 ft. 3 in. deep—dimensions which exceed those of the German vessel by about 80 ft. in length, 16 ft. in beam, and 8 ft. in depth. With regard to power and speed, the Cunarders will be equipped with turbines capable of developing 68,000 h.-p. and the average speed of 24·25 knots an hour, as against the 40,000 h.-p. and speed of 22-23½ of the *Kaiser Wilhelm II.* The *Mauretania* has been built on one of two covered slips especially constructed for the largest types of modern vessels at the Wallsend yard of Messrs. Swan, Hunter, and Wigham Richardson, Ltd. Alongside the slip extensive machine shops were established at an early stage for preparing structural details of the hull, and at a later date a second range of shops was erected and equipped for building heavy frames and floors, and the production of interior fittings. These workshops, in direct communication with the North Eastern Railway by sidings, and with the building slip by electric telphers and cableways, constituted quite an extensive manufactory illustrating the enormous proportions of the vessel, and the infinite amount of work hidden within her hull. The enterprise of the builders in erecting covered berths equipped with overhead electric cranes, and in the provision of the most modern facilities throughout has been amply justified by the satisfactory results obtained in the case of the *Mauretania*. The design of the new Cunarders was treated almost as a matter of national importance. The dimensions and forms of the hulls were determined by the aid of models tested in the Admiralty tank at Haslar, the scantlings were submitted for approval to the experts of the Admiralty, the Board of Trade, and Lloyd's, and the choice of propelling machinery was delegated to a special committee including representatives of the Cunard Company, the Admiralty, Lloyd's, Mr. Brock (of Denny's), Mr. C. A. Parsons, and representatives of the firms to whom the work of construction and equipment was entrusted.

The launching weight of the *Mauretania* was about 17,000 tons, an enormous weight that was lowered through 40 ft. of vertical height within a period of two minutes of the time of launching. In itself this constituted a great engineering feat, which was successfully performed, and the vessel now floats alongside the extensive river frontage of the builders' works. A very large amount of important work remains to be executed in the installation of boilers, machinery and fittings, and some months must necessarily elapse before this magnificent ship will be ready for active service.

Some Notes on Condensers.

By R. M. NEILSON, A.M.I.Mech.E.

THE introduction of the condensing steam turbine with its demand for a high vacuum has caused much attention to be given to condensing plant during the last few years. At high vacua the steam consumption of a turbine is reduced from four to six per cent. per inch increase of vacuum. It is therefore justifiable to incur considerable initial expense and expend a considerable amount of power in order to provide a steam turbine with a high vacuum.

The greater the initial outlay, however, and the greater the power expended, the more call is there for thoughtful and scientific designing of the condensing plant, and also for the careful selection of condensers, pumps, cooling towers, &c., when a condensing plant has to be installed. A power station engineer, of course, wants the condensing plant which will reduce the total cost of running his station to the lowest figure, this total cost, including interest and depreciation, rent, taxes, &c. The condensing plant, of course, affects the steam consumption of the engines, and therefore affects the cost of the boilers to provide the requisite steam. The relative importance of low first cost and low working expenses depends on the load factor of the station; and the design and proportions of the condensing plants, especially the cooling tower, if one is employed, depend to a certain extent on the evenness or otherwise of the daily load curve.

In marine work cooling water in any quantity is obtained for the pumping, and therefore the amount of water used is of less importance than in most land installations, although, on account of the power required for actuating the circulating pump and on account of the weight, bulk and initial cost of the latter, the point is of course not one which can rightly be ignored. In marine work weight especially is of importance—in warships of very great importance—and this consideration calls for condensing plant which is of a great capacity in proportion to its weight

The whole question of the design and selection of condensing plant is of a very complicated nature; and, generally speaking, it is impossible to lay down rules of universal application. Moreover, it cannot be too strongly impressed that a condensing plant which is very suitable in a particular situation may be quite unsuitable for use under different conditions elsewhere. A knowledge of the action of a condenser, however, and of the effect of its capacity and design on the initial cost and efficiency of a steam power plant will allow, after careful consideration of all the facts of the case, of a condensing plant being selected which is best fitted for the position it is intended to fill.

If there were no air in the feed water supplied to a boiler and no air leaked into the engine, exhaust pipe or condenser, the maintaining of a vacuum would be a much simpler matter than it is. In ordinary practice, however—and generally speaking in all cases outside a physical laboratory—air gets into the condenser, and has to be kept down in pressure by being continually withdrawn if the vacuum is to be maintained.

The presence of air is harmful in three ways. Firstly, it requires to be compressed to atmospheric pressure and discharged. Secondly, its presence in the condenser lowers the boiling point, and thus necessitates a lower temperature to condense the steam. Thirdly, it reduces the efficiency of the condensing surface, or in other words it reduces the rate of heat transmission through the

metal from the steam to the water for given conditions as to the difference of temperature, velocity of flow, &c. The last point has recently been investigated by Mr. Jas. A. Smith, of Australia, and the results of Mr. Smith's experiments were given in a paper recently read by him before the Victorian Institute of Engineers, and may be found in THE ENGINEERING REVIEW, Vol. xiv., pp. 341 to 411. Mr. Smith found in short that the greater the amount of air present in the condenser the lower was the efficiency of the condensing surface, and that the rate of fall in efficiency was greater with small than with large amounts of air. That is to say, as the amount of air was increased the efficiency fell, but fell at a continually diminishing rate.

It is therefore of the greatest importance that the air in a condenser should be kept down to the minimum practically possible. The air which can get into a condenser by entering the boiler dissolved in the feed water is limited by the solubility of the gases in water at atmospheric pressure. Even if all the feed for the boiler is fresh water and none is taken from the hot well, the maximum amount of non-condensable gases carried in by the feed water is not great. The amount of air, however, which can find its way by leakage into the condenser is unlimited. There is no doubt that the sizes of air pumps are usually fixed with a considerable allowance for air leakage, and that, if this leakage could be reduced, the air pump capacity could be diminished with a consequent saving in initial outlay and in power absorbed during working.

To condense a given amount of saturated steam at a given pressure, a certain quantity of heat must be abstracted from the steam, and if this is done by means of water, the same quantity of heat must be absorbed by the water. The amount of water required to condense a given quantity of steam at a given pressure therefore depends on the difference between the inlet and the outlet temperatures of the water. The inlet temperature of the condensing water supplied to a condenser is out of control unless a cooling tower or its equivalent is employed, and even then the temperature is controllable only to a slight extent. The outlet temperature of the water from the condenser is, however, controllable to a large extent—it depends on the design of the condenser.

The temperature of discharge of the circulating water from a surface condenser is commonly from 10° to 25° F. below the temperature corresponding to the vacuum. It can, however, be anything up to, and even in some cases slightly above, the temperature corresponding to the vacuum. In a jet condenser the temperature of the discharge water — the injection water plus the water of condensation—may be as high as 6° F. below the temperature corresponding to the vacuum; but this can only be in condensers of the counter-current type, where the air and vapour flow in an opposite direction to that of the condensing water. The counter-current arrangement is shown in Fig. 1, which illustrates a "Weiss" condenser. It will be seen that the exhaust steam enters the condenser considerably below the condensing water; and the air and vapour flow upwards against the flow of the water, the air thus meeting the coldest water last. The condensing water can therefore be cut down to a minimum, and a high water discharge temperature thus attained. The air is drawn away by an air pump, and the water of condensation is delivered to the hot well by means of the barometric pipe, no hot well pump being required.

In parallel current jet condensers where the air flows in the same direction as the condensing water, the temperature of discharge of the water is necessarily lower as more water has to be employed. If the amount of condensing water employed is of any consequence—and it usually is—it is obviously desirable to have the discharge temperature as high as possible. This is especially the case where cooling towers or equivalent devices are employed. Suppose, for example, that a surface condenser and cooling tower

are employed and that a vacuum of 27·25 in. has to be maintained, the temperature corresponding to which is 112°. Suppose that the temperature of the water returned to the condenser from the tower is 86°. Then, if the temperature of discharge of the circulating water from the condenser is 97°,

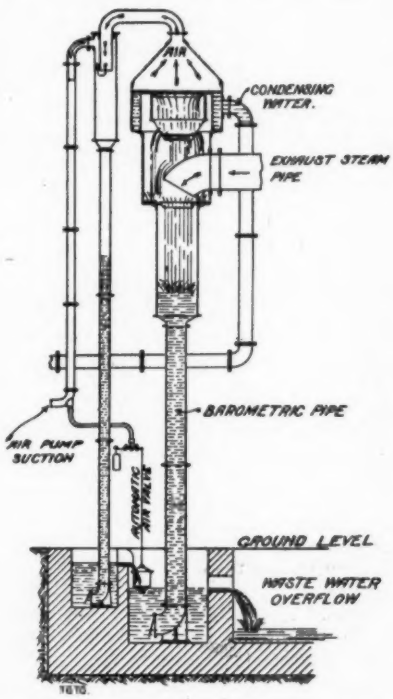

FIG. I.—"WEISS" COUNTER-CURRENT JET CONDENSER.

the range of temperature is 11, that is, each lb. of water absorbs 11 B.T.U.'s from the steam. The exact amount of heat to be withdrawn from the steam depends upon its dryness; but, assuming 1,000 B.T.U.'s per lb. of steam, it follows that 1,000/11 or 91 lbs. of water will be required per lb. of steam. If, however, the circulating water is discharged from the condenser at a temperature of 108°, its range of temperature is 22°, and only 1,000/22 or 45·5 lbs. of water will be required for each lb. of steam. The water will thus be halved in amount. This will not only reduce the power required to pump the water up to the distributing troughs of the cooling tower but will very materially affect the size and cost of the tower.

That the amount of circulating water per lb. of steam can be limited to the amount just mentioned is conclusively proved by the experiments recently completed by Prof. Weighton, the results of which are contained in the valuable paper which he read before the Institute of Naval Architects last April. See THE ENGINEERING REVIEW, Vol. xiv., pp. 418 to 428. To take one test only, in trial No. 1,002, with a "Contraflo" condenser having a cooling surface of 100 sq. ft., Prof. Weighton obtained a vacuum of 27·57 in. (referred to a barometer of 30 in.). The temperature corresponding to this vacuum is 108° F., and the outlet temperature of the circulating water during the test was slightly higher than this—namely 108·8°. Taking 1,000 B.T.Us. per lb. of steam, as assumed above, the quantity of circulating water per lb. of steam would be 16·18 lbs. The actual amount measured was 16·21 lbs.

The capacity of a surface condenser, that is, the amount of steam which it can condense per hour, depends upon the extent of the cooling surface and the rate of heat transmission through the metal plates from the steam to the circulating water. The term plate is used to designate the metal which separates the steam from the circulating water. As a rule this consists of the sides of a tube.

Now in the transmission of heat from the steam to the circulating water there are three operations: (1) The transfer of the heat from the steam to the plate; (2) The conduction of the heat through the plate; and (3) The withdrawal of the heat from the plate by the water.

It is convenient to discuss the three operations one by one.

(1) *The Transfer of the Heat from the Steam to the Plate.*—This depends upon the velocity of the steam and the wetness and cleanness of the plate. The greater the velocity of the steam, the more readily can its heat be transferred to the metal; but, under usual condenser conditions, the rate of transfer of heat seems not to be directly proportional to the velocity but to a lower power of the velocity. As regards the wetness of the plate, the best condition is probably when the plate is damp but the film of water very thin. Steam seems to give up its heat to metal more readily through the agency of a layer of water than directly; but too thick a layer increases the resistance to the flow of heat, water being a poor conductor. Certainly in condensers of the "Contraflo" type, in which all the water of condensation, except what clings to the tubes, is drained off almost as soon as formed, the rate of heat transmission is high.

A deposit of grease on the plate is found to adversely affect the transfer of heat to it, and hence the advisability of cleaning the condenser frequently if greasy steam has to be dealt with, or adopting the alternative, and generally preferable course, of extracting the greater and most readily deposited portion of the grease in a grease separator before allowing the steam to enter the condenser.

(2) *The Conduction of the Heat through the Plate.*—This is affected by the thickness of the plate and by the material of which the plate is constructed; but in condensers these factors influence the rate of heat transmission from the steam to the water so little that the metal to be employed and its thickness are mainly determined, and rightly so, by considerations of strength, weight and lasting properties.

(3) *The Withdrawal of the Heat from the Plate by the Water.*—This depends on the cleanness of the plate on the water side, any deposit of scale on the plate adversely affecting the transfer of heat. The velocity of the water is a very important factor; but its importance seems to vary in different cases. In the case of a "Contraflo" condenser tested recently by Professor Weighton,* the rate of heat transmission was found to be exactly proportional to the velocity within the limits of the tests, *i.e.*, the weight of steam condensed per sq. ft. of cooling surface was exactly proportional to the velocity of the circulating water.

The rule must not however be taken as being universally applicable, as is conclusively shown by the fact that very different rules have been deduced by other experimentors from tests made under different conditions. No rule connecting the rate of condensation with the velocity of the water can be of universal application that does not take into account the arrangement and condition of the cooling surface, which undoubtedly have a most important effect on the transfer of heat.

It is common marine practice to have one sq. ft. of condenser cooling surface for every 10 lbs. or so of steam taken per hour by the engine when running at full power; and with condensers of the ordinary marine type this allowance of cooling surface may be taken as correct. In condensers used with steam turbines where a high vacuum is called for, a more liberal allowance of cooling surface is usually made; and, where the circulating water is in the region of 80° F. and a high vacuum is desired, there may be one sq. ft. of surface for only 4½ lbs. of steam. There is no doubt however that, with conditions favourable for a high rate of heat transmission, much more than 10 lbs. of steam can be condensed per sq. ft. of surface per lb. even when a high vacuum is required. Prof. Weighton with a "Contraflo" condenser has dealt without difficulty with 35 lbs. of steam per sq. ft. and maintained a vacuum of 28·3' in. The obtaining of a high rate of condensation is simply a question of design, accompanied of course by good workmanship. The fault of most surface condensers is that, while one sq. ft. of cooling surface may be very efficient, another, owing to its being drowned in water or situated in a stagnant corner of

* Cf. ENGINEERING REVIEW *loc. cit.*

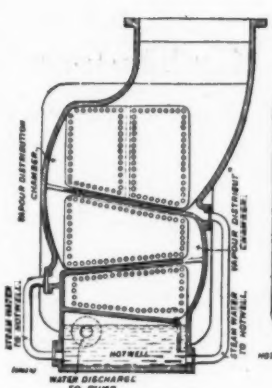

FIG. 2.

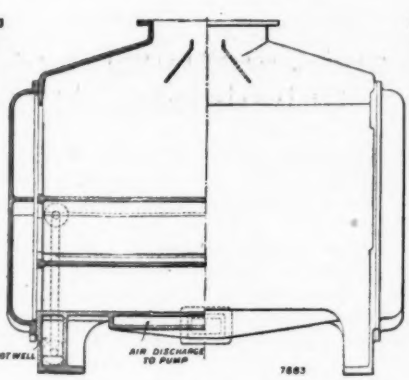

FIG. 3.

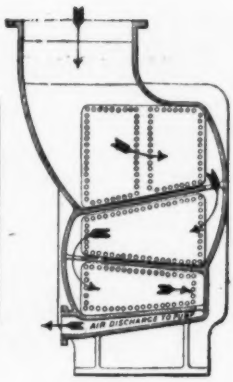

FIG. 4.

"CONTRAFLO" SURFACE CONDENSER.

the steam space, is very inefficient. The general law in design should be to level up all the parts of the cooling surface, making them as far as possible equally efficient.

An example of a good design in a surface condenser is given by Figs, 2, 3 and 4, which illustrate a surface condenser of the "Contraflo" type. The direction of flow of the steam is shown by the arrows in Fig. 4. The steam enters at the top and passes in succession through the three condensing chambers which are made to gradually diminish in section, so that, as the steam is gradually condensed, its velocity remains approximately constant. The tubes are at right angles to the motion of the steam; and the water enters at the bottom and makes several passes through the tubes before leaving the condenser at the top. The air thus leaves the condenser after passing over the coldest tubes, and thus with a minimum volume and containing a minimum amount of water vapour.

The passages or distributing chambers leading from one condensing chamber to another are tubeless. They extend the whole length of the condenser and are shaped so as to distribute the steam equally over the tube surface. The design thus differs materially from the ordinary counter current surface condenser, in which the tubes are parallel to the direction of flow of the steam and the latter is not uniformly distributed over the cooling surface.

The water is drained from each chamber by a separate pipe or duct which conveys it to a small hot well situated at the bottom of the condenser. This arrangement keeps the lower tubes of the condenser comparatively free of water, and allows of a high condensation rate being obtained, while it has another important advantage in that the hot well benefits in temperature by having the relatively hot water from the top chamber conveyed to it by a special passage instead of getting cooled and acting harmfully to heat the circulating water by dripping down to the bottom of the condenser.

The Design and Construction of Mechanical Calculators.—II.

By WILLIAM J. GOUDIE, B.Sc., A.M.I.Mech.E.

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THE factorial expression $R = \frac{M\,N}{P\,Q}$ is only a particular form of the general type, $R = \frac{M^x\,N^y}{P^z\,Q^v}$, where each of the exponents x, y, z, and v is unity. When these exponents have values greater or less than unity, the scalar embodiment of the expression becomes more troublesome. According to the rule for involution and evolution the logarithmic statement of the expression is, log. $R = x$ log. $M + y$ log. $N - z$ log. $P - v$ log. Q.

If log. M is represented in Fig. 6 by the length a, measured from the $Y\,Y$ or index line of the primary logarithmic scale, then x log. M will be a length which will contain the log. M or a length x times.

Suppose that $x = 1{\cdot}5$ and $M = 5$, then the value of x log. M is located at m, distant $1{\cdot}5\,a$ from $Y\,Y$. If $y = 2$, $N = 16$, and the length $b = \log. N$, then the value of y log. N is located, on the movable scale at n, distant $2\,b$ from its index line. By placing the N index line at m, the sum of the distances $1{\cdot}5\,a$ and $2\,b$ is located opposite n on the movable scale at q on the fixed scale, distant c from the index line $Y\,Y$; and the reading on the fixed logarithmic scale is $M^x\,N^y = 5^{1{\cdot}5} \times 16^2 = 2863$.

This semigraphical method is not of much practical value, but it serves to indicate that the desired result can be obtained by making the unit lengths of the scales proportional to the indices of the powers of the factors, for what holds for the above numbers holds equally for unit values. When this is done the respective scale units will be x, y, z, and v times the length of the unit of the base scale, or that of the R element, whose exponent is unity.

On such a proportional M scale the value marked 10 is actually 10^x; on scale N that marked 20 is 20^y; on scale P that marked 50 is 50^z; on scale Q that marked ·5 is $\cdot 5^v$; and hence, on account of this arrangement, the operator does not need to trouble about the powers of the factors when manipulating the combination.

The necessary set of scales can be obtained by marking the mantissae values on each proprotional unit length, in the manner already described and

NOTE.—Owing to an oversight, Figs. 2 and 5 in Mr. Goudie's first article were transposed. For Fig. 2, therefore, page 184, *read* Fig. 5, and for Fig. 5, page 189, *read* Fig. 2.—ED.

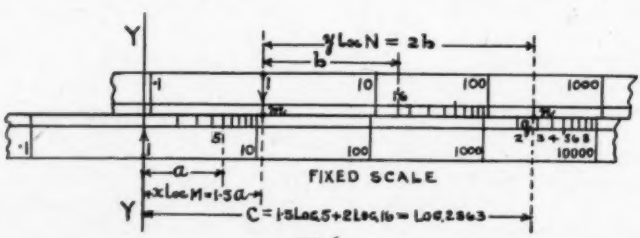


FIG. 6.

illustrated in Fig. 4*; but although this construction is necessary for a clear demonstration of the application of first principles, it is too tedious for practical purposes, and in the final stage of the design it need not be employed when a machine-cut slide rule is available, from which a unit length of the scale and its subdivisions can be ticked off on a strip of paper, with a degree of accuracy that it is not possible to attain on a constructed scale. This unit can be used either as the base scale unit, or that of any other scale of the set. Its dimensions can be enlarged or reduced in the necessary proportion for each scale, either by the geometrical method illustrated in the chart article, or by a pair of proportional dividers, or, failing these, by stepping out the divisions with a pair of ordinary dividers. This latter method necessitates the exercise of a good deal of care, on account of cumulative errors that are liable to occur. It is usually the case, no matter how carefully the enlargement or reduction is carried out by any of these methods, that there are slight inaccuracies in the derived scales, and each should be tested, and rectified if necessary, before it is transferred to the instrument. This testing can be done by placing a blank scale against the derived scale, carefully lining it across the blank one, in duplicate, like the scale of an ordinary slide rule, and then making a number of trial multiplications and divisions with the two scales. Thus, if the index line of one scale is set against 2 on the other one, every value on the movable scale ought to be coincident with double its value on the fixed scale, and so on for any other multiples. When transforming any scale the main divisions of the unit should be very carefully located and tested before the sub-divisions are lined in.

Location and Adjustment of Scales and Index Lines.—The choice of the base scale unit is dependent on two conditions: In the first place it must be such that with the most compact arrangement of scales the length of the instrument will be kept within reasonable limits, and in the second, that the values on the scale of the factor, which has the smallest fractional exponent, may be read with the degree of accuracy demanded by the nature of the problem.

The location of the arbitrarily constant numerator and denominator scales on the edges of the slides, and their lengthwise adjustment for the production of a compact, easily read and easily handled combination, constitutes the first and probably the most important stage of the design, and merits a careful consideration. The most suitable order of the scales, for any case, can only be ascertained by considering it on its merits; but when this has been decided the location and adjustment of the scales on the upper and lower edges of their respective slides can be expeditiously carried out, according to definite rules.

To ascertain the rule for location, take the simpler of the two foregoing expressions, $R = \frac{MN}{PQ}$. This may be written in the following forms: (*a*) $R = \left(\frac{N}{PQ}\right) M$, (*b*) $R = \left(\frac{M}{PQ}\right) N$, (*c*) $R = \left(\frac{MN}{Q}\right) \frac{1}{P}$, (*d*) $R = \left(\frac{MN}{P}\right) \frac{1}{Q}$, the bracketed quantities, in each case, being the factors chosen as arbitrary constants.

For convenient handling of the instrument, it is usually advisable to reverse the order of the scales shown in Fig. 5,* and to make the lower fixed scale that of the independent variable, and this convention will be observed in what follows. In order to check the results obtained by different combinations, let $M=10$, $N=20$, $P=4$ and $Q=2$. Consider case (*a*): The independent variable is M, and hence in Fig. 7, its scale is made the lower fixed one. Let the arbitrarily chosen order of the movable scales reading from M to R be N, P and Q. The N scale is placed on the slide adjacent to M, and since N is a multiplier

* Vol. xv., p. 189.

* Vol. xv., p. 184.

the N index line must traverse the M scale when the slide is moved, so that when this index line is brought against $M=10$ the value $N=20$ may come in line with the product 200 on the R scale. The P scale is placed on the next slide, and since P is a divisor the value $P=4$ must be brought against $N=20$, and in line with $R=200$, so that the P index line may come in line with the quotient 50 on the R scale. To fulfil this condition it is evident that the N scale must be placed on the upper edge of its slide and the P scale on the lower edge of its slide. The Q scale is placed on the remaining slide, and since Q is also a divisor the value $Q=2$ must be brought against the P index line or in line with $R=50$ so that the Q index line may indicate the final result $R=25$ on this scale. Now suppose that the order of the scales is changed to P, Q and N. The P scale in Fig. 8 is placed on the slide adjacent to M and the value $P=4$ must be brought against $M=10$ so that the P index line may come in line with the quotient 2·5 on the R scale. The Q scale is placed on the next slide and the value $Q=2$ must be brought against the P index line so that the Q index line may come in line with $R=1{\cdot}25$, and to accomplish this end it is evident that again the P and Q scales must be placed on the lower edges of the slides. The N scale is placed on the last slide and its index line must be brought against the Q index line so that the value $N=20$ may coincide with the final result $R=25$. The N scale must therefore be placed, as before, on the upper edge of its slide. In case (b) the M and N scales will simply change places, and the foregoing remarks therefore apply equally to it when M is substituted for N.

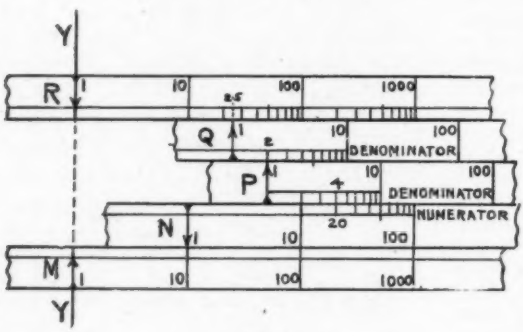


FIG. 7.

This examination shows that, in general, when the lower fixed scale is chosen as that of the independent variable the numerator scales are located on the upper edges and the denominator scales on the lower edges of the slides. An additional condition, however, is revealed by Fig. 8, which is of the first importance from the constructional point of view. In whatever position the Q scale is placed relatively to the M and P scales, the N scale relatively to it will occupy the position shown, since the N and Q index lines must coincide in the final stage of the calculation. The N and Q slides can therefore be fixed together and moved as one slide, without affecting the final result.

This amalgamation, while it does not affect the above rule of location, reduces the sliding members by one, and further eliminates the N and Q index lines from the solution. Now the P index line can be read as the log. 1 value of a scale either on the lower or upper edge of the slide, so that if another numerator factor S is introduced into the expression its scale can then be placed on this upper edge, and the common P and S index lines will then be eliminated from the solution.

It will be seen that when there are four arbitrary constants in the right hand side of the equation, two in the numerator and two in the denominator, the minimum number of slides is two.

Now, suppose that the expression takes this form, $R = \dfrac{M\,N\,P\,Q}{S}$, in which there are more arbitrary constants in the numerator than in the denominator. In this case, the denominator scale S

would be placed on the lower edge of the lower slide and any two of the numerator scales, say N and P, on the upper edges of the two slides. There remains the Q scale, which is a numerator one and which, at first sight, appears to necessitate the employment of a third slide, in accordance with the above rule of location. In a case like this the important principle of scale inversion can be advantageously employed, and a word regarding it is necessary.

When one number is divided by another it is multiplied by the reciprocal of the other number; thus $\frac{a}{b} = a \times \frac{1}{b}$. When the numbers are multiplied, one number is divided by the reciprocal of the other; thus $a \times b = \frac{a}{\frac{1}{b}}$.

Instead, therefore, of using the value of the factor Q directly as a multiplier its reciprocal may be used as a divisor, and its reciprocal scale can be placed on the lower edge of the upper slide, in accordance with the rule of location. Now since $1 \times \frac{1}{10} = \cdot 1$, $1 \times \frac{1}{100} = \cdot 01$, $1 \times \frac{1}{\cdot 1} = 10$, and $1 \times \frac{1}{\cdot 01} = 100$, it will be evident that if a scale of reciprocal values is placed with its index or log. 1 line against the log. 1 value of the primary logarithmic scale the $\cdot 1$ and 10 values on the reciprocal scale will coincide with the 10 and $\cdot 1$, and the $\cdot 01$ and 100 with the 100 and $\cdot 01$ values on the primary scale. The reciprocal scale can therefore be obtained by simply setting off the integral log-values to the left, and the fractional ones to the right of the datum or index line. In other words, the reciprocal scale is the primary logarithmic scale reversed.

For brevity of statement in what follows, the ordinary logarithmic scale, whose values read in ascending order from left to right, will be termed a "direct" scale, and the reciprocal scale whose values read from right to left, an "inverted" scale.

The introduction of this principle of scale inversion leads to an extension of the rule of location, which may be expressed thus: Numerator scales are located on the upper and denominator scales on the lower edges of the slides, when "direct" scales are used throughout. When the number of numerator scales exceeds the available number of upper edges, an inverted numerator scale may be placed on a lower edge; and *vice versâ* in the case of a denominator scale.

Referring again to the four forms of the expression, it will be noted that in (*a*) and (*b*) the factors chosen as independent variables are numerator ones, while

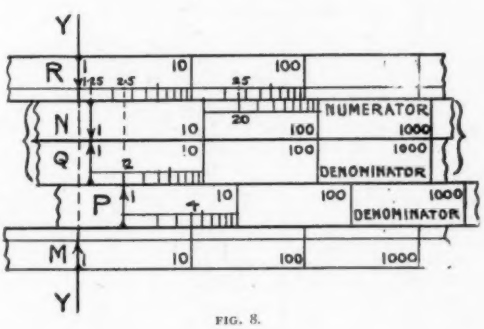


FIG. 8.

in (*c*) and (*d*) they are denominator factors.

In the former the bracketed quantity is multiplied by the actual factor value, in the latter by the reciprocal one. A little reflection will show that, in the case of (*c*) or (*d*), when either the P or Q scale is made the lower fixed one it must also be inverted.

Next, for the purpose of ascertaining definite rules for the adjustment of the scales, and to make the demonstration as comprehensive as possible, let the factor S be introduced in the numerator of the general expression, and let $x=3$, $y=2$, $z=\frac{3}{5}$ and $V=\frac{3}{2}$, so that the expression now becomes $R = \frac{M^3 N^2 S}{P^{\frac{3}{5}} Q^{\frac{3}{2}}}$. Let the order of the scales be, M (lower fixed) P, N, Q, S and R (upper fixed),

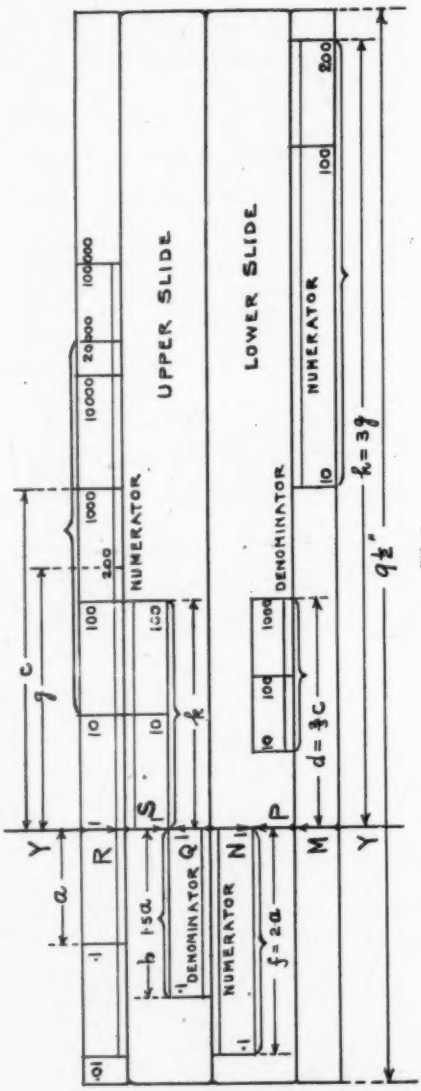

UPPER SLIDE
LOWER SLIDE
NUMERATOR
DENOMINATOR
NUMERATOR
DENOMINATOR
Y
R
S
Q
N
P
M
Y
a
b = 1.5a
f = 2a
d = ⅓c
k = 3g
9½"
c
g
k

FIG. 9.

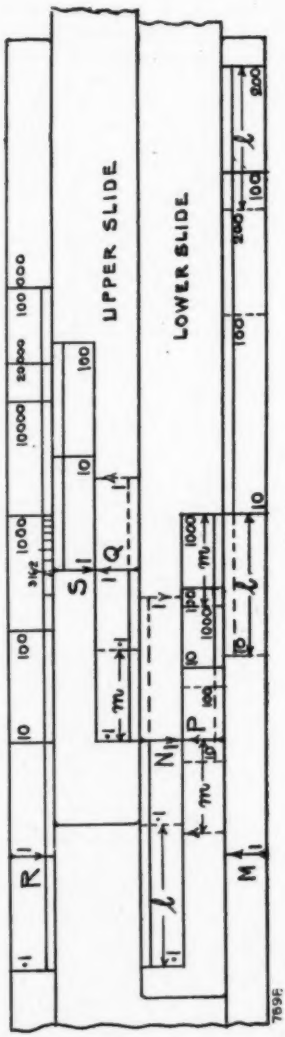

UPPER SLIDE
LOWER SLIDE
R
S
Q
N
P
M
m
l
7698

FIG. 10.

and the ranges of value of the various factors, M 10 to 200, P 10 to 1,000, N ·1 to 1, Q ·1 to 1, S 1 to 100 and R 10 to 20,000. For the purpose of this mechanical analysis, a primary arrangement of block scales, having 1 in. as the base unit, is quite sufficient.

Since, as already pointed out, two slides are required to take the movable scales, draw in the four scale compartments on a sheet of bristol board, and on the upper scale line (Fig. 9) set off the "direct" R scale. As the two numerator scales go on the upper, and the two denominator scales on the lower edges, and the M scale is a numerator one the rest of the scales will also be "direct."

Begin with the Q scale and obtain its maximum length limit by setting off to the left of YY the length $b = 1{\cdot}5$ $a = 1{\cdot}5$ (distance between 1 and ·1 on the base scale). Next to the right of YY set off the distance $k =$ (distance between 1 and 100 on the base scale) and obtain the maximum length limit of the S scale. Repeat this process for the N, P and M scales, making $f = 2a = 2$ (distance between 1 and ·1), $d = \frac{2}{3}c = \frac{2}{3}$ (distance between 1 and 1,000) and $h = 3g = 3$ (distance between 1 and 200). In the same manner fix the minimum length limit of each scale; and the portions of the scales within these limits, indicated by the brackets, constitute the working parts of the combination. When this primary arrangement of block scales, each scale having the common datum or index line YY as its log. 1 value, has been lined in as shown (Fig. 9), it will be found that, with such a small base unit as 1 in. it requires an instrument at least 9½ in. long to take it in, so that with a sufficiently enlarged unit, to enable results to be obtained with any degree of accuracy, the finished instrument would become unwieldy in size. The primary arrangement is essentially a crude one, but fortunately it is not necessary to adhere to it. By judicious adjustment of the scale lengths a condensed arrangement to give precisely the same results as the primary one can be obtained. For the purpose of this adjustment, cut the card along the three scale lines, to obtain the two slides, and pin down the M and R scales. Keeping the upper slide fixed, move the lower one to the right till P = 1,000 coincides with $M = 10$ (Fig. 10) then the common P and N index line will be in line with $R = 10$, while $N = {\cdot}1$ will be in line with $R = {\cdot}1$. Keeping the lower slide fixed, move the upper one till $Q = {\cdot}1$ coincides with $N = 1$, and the common Q and S index line will coincide with $R = 316{\cdot}2$, or $S = 10$ will coincide with $R = 3162$. The correctness of these figures can be checked by calculation. Now, suppose the M scale is shifted l distance to the left, then if the lower slide is kept fixed it is evident that the P scale must also be shifted l distance to the left in order that $P = 1{,}000$ may remain coincident with $M = 10$. If the P scale is not shifted, then when the slide is moved l distance to the left it will carry the N scale with it to the left also. In order, then, to maintain the coincidence between $N = 1$ and $Q = {\cdot}1$, the N scale must be shifted the distance l to the right, as shown by the dotted scale. Next, assuming that the M scale is not shifted, but that the P scale is shifted a distance m to the left, then the N scale must obviously be shifted m distance to the left also, so that when the slide is moved back to bring $P = 1{,}000$ into coincidence with $M = 10$, $N = 1$ may be coincident with $Q = {\cdot}1$. On the other hand, if the P scale is shifted and the N scale is kept in the primary position, then when the slide is moved back, the N scale will also move back m distance with it, and to maintain the coincidence between $N = 1$ and $Q = {\cdot}1$, as before, the Q scale must be shifted m distance to the right of its primary position. It will also be evident, from what has been said in connection with the M and P scales, that if it is required to shift the R scale, either the S scale will have to be shifted the same amount in the same direction, or the Q scale will have to be shifted in the opposite direction. Finally, two traversing scales on adjacent slides may obviously be shifted the same amount in the same direction

without affecting the positions of the other scales.

In addition to these adjustments, which are purely mechanical and arbitrary, there is, in the majority of cases, a further adjustment which is compulsory. The right-hand side of the general expression really contains six factors, the sixth being unity. Any other number or absolute constant (for which no scale is necessary) may, however, occur in place of it. Denoting such an invariable number by the general symbol, C., the expression becomes, $R = \frac{C\,M^3 N^2 S}{P^{\frac{2}{3}} Q^{\frac{3}{2}}}$, and C may be regarded as a co-efficient of any one of the numerator factors. Taking it as the co-efficient of N and equal to 10, then instead of the $N=1$ or unit value coming in line with $R=10$ (Fig. 10), it would require to come in line with $R=100$, that is, the N scale would have to be shifted to the right of the primary position a distance equal to log. 10, measured in terms of the base scale unit, all the other scales meantime remaining in the primary position. The same result could, however, be got by shifting the P scale to the left, for when the lower slide is moved back till $P=1{,}000$ is coincident with $M=10$, the N index line will be moved the same amount to the right, and will coincide with $R=100$.

The adjustment for an absolute numerator constant can therefore be made by a positive shift of a direct numerator scale or a negative shift of a direct denominator one on any slide.

If, however, C occurs in the denominator, it will be evident that this adjustment rule will be simply reversed. In any case, where an inverted numerator scale is shifted, the scale will require to get a negative shift: a similar reversal will be necessary in the case of an inverted denominator scale.

With regard to the number of slides required in any given case, it will be seen, from the foregoing, that of the n variable elements $(n-2)$ have movable scales. In the first case $n=5$ is an odd number; in the second $n=6$ is an even one, and in both cases two slides are required. In the first, three slide-edges or one-and-a-half slides are occupied by the scales; in the second the four edges or both slides are occupied. In the first, half the number of movable scales gives the number of slides occupied less one half; while in the second it gives the exact number. It is very seldom that any expression containing any more than six elements has to be dealt with, and hence a two-slide instrument is sufficient for all ordinary requirements.

Collecting the results of the foregoing discussion, the following set of working rules may now be formulated.

Rules for the Design of Straight Slide Calculators.—Given any factorial expression, involving n variable elements, which is to be embodied in a scalar calculator of the straight slide type, then :—

I. The minimum number of slides $= \begin{cases} \frac{(n-2)}{2}, \text{ when } n \text{ is even.} \\ \frac{(n-2)}{2} + \frac{1}{2}, \text{ when } n \text{ is odd.} \end{cases}$

II. When the lower fixed scale is made that of the independent variable, direct numerator, and inverted denominator, scales are placed on the upper edges, and direct denominator and inverted numerator scales are placed on the lower edges of the slides. If a denominator scale is chosen for that of the independent variable it must be inverted.

III. The unit length of each factor scale must be made equal to (base scale unit × exponent of the power of the factor).

IV. A fixed scale and the traversing scale on the adjacent slide, or the traversing scales on adjacant slides may be shifted the same amount in the same direction.

V. The lower-edge scale on any slide may be shifted if the upper edge scale is shifted the same amount in the same direction; but if the upper edge scale is not shifted, then the lower edge scale on the adjacent slide must be shifted the same amount in the opposite direction.

VI. When an absolute constant occurs as a numerator coefficient, a direct

numerator scale must get a positive shift, and an inverted numerator one a negative shift, equal to the log. value of the constant, measured in terms of the base scale unit. Conversely a direct denominator scale must get a negative shift and an inverted denominator scale a positive shift. When the constant occurs as a denominator co-efficient the above order of adjustment is reversed.

In connection with this last rule it frequently happens that the value of the constant runs into four or more figures, and a single scale adjustment becomes impracticable. The difficulty can be overcome, by splitting the constant into suitable components, and adjusting the various scales in accordance with their values. Illustrations of this adjustment will be given at a later stage.

(To be continued.)

Admission and Exhaust Valves used in Petrol, Gas, and Oil Engines.

By EDWARD BUTLER, M.I.M.E., A.I.E.E., Etc.

As internal-combustion or explosion engines are actuated by gaseous pressure generated within the working cylinder from the combustion of explosive mixtures, the ordinary distributing valves, which have proved so successful in the working of the steam-engine, are not adapted for the explosion-engine on account of the pressure generated within the working cylinder being greater than the pressure at the back of the valve.

In the early atmospheric type of gas engine and in some compression engines of more recent construction, slide-valves have been used with a fair amount of success, these, however, have not been of the pattern as ordinarily used in fluid pressure engines and which can be held up to the cylinder face by the pressure of the actuating fluid; but in all cases have been formed with two parallel sides, each of which necessarily had to be accurately machined to enable the valve to slide between the cylinder face and the retaining cover. The principal reason for using this expensive form of valve in the earlier engines was to obtain a reliable ignition of the mixture within the working cylinder by a flame, the valve being provided with a flame pocket, by which means a little portion of inflamed mixture was capable of being brought into contact with the contents of the mixture at the correct moment for igniting the charge under pressure; the valve as well as the spring retained back cover having been generally provided with separate air and gas ports in addition to the flame flue and pocket.

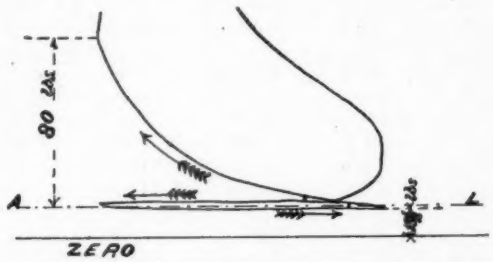
In practice, the use of slide-valves has been found to be attended with considerable inconvenience and inefficiency on account of leakage of gas into the engine room, from fumes from the pilot flame and ignition port and from loss of power through mis-ignition of the cylinder charge. The valves, moreover, required very careful adjustment, and were expensive to keep in repair, refacing being found necessary after a few hundred hours working. In the atmospheric type of gas engine as made between the period of 1860 to 1876 and in some non-compression engines of a later date, slide-valves were also used and provided a means for obtaining a quick cut-off to the mixture supply and suction of ignition flame.

Although piston-valves and, in some cases, even rotary valves of disc and cylindrical form have been used in engines working on the four and two-cycle systems, the poppet valve remains to-day practically alone; this type of valve, with its hammering or tappet beat, its cam and spring and half speed shaft, being in universal use for all types of explosion engines, both large and small. The gradual increase in the degree of compression during the last ten years from 40 lbs. as used in engines of the slide-valve type to 75 lbs. as used to-day in engines working with town-gas and from 120 to 150 lbs. per sq. in. for the larger engines using producer and furnace gas, has demanded a valve capable of maintaining under everyday conditions a more perfect gas tight fit than could be obtained from either the old type of cylindrical, disc, or any other form of slide-valve.

The supercession of flame-ignition by the introduction of the incandescent-tube in the ordinary gas engine no doubt considerably influenced the abandonment of the slide-valve. Then again, the slide-

valve was never found suitable as an exhaust valve, excepting in the very small size engines, and as a consequence of this one poppet at least was found necessary for each cylinder, and it only remained to further utilise the half-speed shaft by providing a second poppet for the admission of the charge, and to duplicate the cam, lever and spring in order to dispense with the slide form

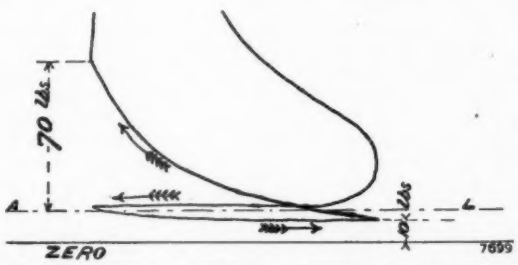
twice the power that could be obtained from the same size cylinder eight years ago. Properly timed ignition and the supply of properly carburetted explosive mixture has had much effect in making this improvement possible. The principal factor, however, after deducting all other influences, must be explained to be due to the increased lung power as afforded by correctly timed and perfectly



Scale, $\frac{1}{12}$ in.

Piston speed, 800 ft. per minute.

SHOWING ADMISSION, COMPRESSION, AND EXHAUST LINES ON FOUR-CYCLE ENGINE RUNNING WITH THROTTLE FULL OPEN.



Scale, $\frac{1}{12}$ in.

Piston speed, 800 ft. per minute.

SHOWING ADMISSION, COMPRESSION, AND EXHAUST LINES ON FOUR-CYCLE ENGINE RUNNING SLIGHTLY THROTTLED.

FIG. 1.

of valve altogether; the ignition being obtained from a third smaller lift valve used to control the timing of the charge contact with the incandescent-tube.

The modern tendency is always towards the attainment of higher and higher power and speed from an engine with a cylinder of a given size; so much for instance has the power efficiency increased in the automobile class of motor, that a motor of to-day is capable of developing considerably more than

gas-tight valves of large area, thus permitting higher speeds and working pressure with a proportionate reduction in loss of power from the negative pressure of the exhaust and suction strokes.

In all engines the power efficiency of a cylinder of a given size is much reduced by wire drawing or throttling of the explosive mixture supply on the admission strokes of the engine; this effect is graphically illustrated by the suction

or induction, compression and exhaust stroke diagrams (Fig. 1), which show clearly the increased power efficiency that can be obtained by reducing the negative resistance on the suction line. This improved working effect can only be obtained by using large inlet valves giving a very free opening, and by having all the branch pipes for the air; gas or oil supplies arranged to oppose a minimum resistance. These particular diagrams illustrating this effect were taken from an engine having a combined admission and exhaust plug valve, with portways for the admission and exhaust of such a size as to limit the mean velocity of the ingoing or outgoing gases past the portways in the valve or seat to a maximum of from 90 to 100 ft. per second, corresponding to a piston speed of 13 to 14 ft. per second. The pipes used to conduct air to the mixer and the exhaust to the atmosphere should be large enough to give a velocity of inflow or outflow of some 80 ft. per second, and no unnecessary bends should be used. It is also important to use a speed regulator of correct design to give governor control without undue throttling, *i.e.*, provided the engine is arranged to be controlled in speed by varying the volume of mixture supply as now most generally adopted in all engines except in some of the largest size, which are provided with free opening variable cut-off valves in order to minimise the resistance to the flow of mixture to the cylinder to a fine point.

Referring to the two diagrams, the first shows a suction resistance of slightly over 1 lb. per sq. in., and gives a compression pressure of 80 lbs.; now, on looking at the second diagram, it will be seen that it corresponds very closely to a fairly good gas, oil, or petrol engine running at full load and speed. The suction line in this case is 10 lbs. above absolute pressure, *i.e.*, it indicates a negative resistance of some 4 lbs. per sq. in. and results in obtaining 10 lbs. less compression pressure than in the other case. There is thus a discrepancy shown of nearly 15 per cent. in the power value of these two diagrams; it does not, therefore, follow that an engine is by this amount more efficient from the point of view of fuel consumption, as the greater loss of exhaust pressure in the full diagram nearly counter-balances the increased negative resistance caused by the deeper suction line. The point is, however, that an engine with a larger valve and freer opening is capable of a higher power duty when called upon, as for instance in an automobile, where minimum weight and size of motor is of material consideration.

The piston speed in both these cases was identical, *i.e.*, 800 ft., or thereabouts, per minute, and it will be seen that an engine provided with valves capable of giving a diagram with a minimum practical resistance as shown by the first of these diagrams would be well capable of being accelerated to a piston speed of 1,000 ft. per minute or more, with less loss of efficiency than would result in an engine fitted with valves proportional to a diagram with the 70 lbs. compression for instance. At slower speeds, below 500 ft. per minute, there would not be any appreciable difference in the running of the two engines, and on the other hand the higher the speed above normal the more is the power efficiency of the engine influenced by the correct working and large opening of the valves.

At this point it will be interesting to note the valve diameters required to keep down the velocity of the inflow or outflow to within 100 ft. per second, the diameters being given in the following table to correspond with cylinder diameters having piston speeds taken at 840 ft. per minute, thus corresponding to 14 ft. per second. The diameters of the admission valves may be taken at about 5 per cent. less than the sizes given, and the exhaust valves at 5 per cent. larger, in order to compensate for the difference in volume of the contents of the cylinder at the end of the charging stroke, as compared with the volume of gases to be exhausted; the admission charge being about 13½ lbs. absolute, and the exhaust about 15½ lbs. absolute. The pipes both for admission and exhaust should give a further increased

area if carried to any considerable distance.

TABLE OF VALVE AND CYLINDER DIAMETERS.

Diameter of Cylinder.	Diameter of Valves.	Diameter of Cylinder.	Diameter of Valves.
3 in.	1⅛ in.	15 in.	5½ in.
3½ "	1⅝ "	18 "	6¾ "
4 "	1½ "	21 "	8 "
5 "	1⅞ "	24 "	9 "
6 "	2¼ "	27 "	10½ "
7 "	2⅝ "	30 "	11⅝ "
8 "	3 "	33 "	12½ "
9 "	3⅜ "	36 "	13½ "
10 "	3¾ "	42 "	16 "
11 "	4⅛ "	48 "	18 "
12 "	4½ "	54 "	20 "

Much attention has been given to minimising the fluid resistance caused by the suction and exhaust strokes of the gas engine, and provided this can be reduced to a negligible quantity, there will remain no reason except the mechanical balancing of the moving parts to prevent an explosion engine from working at considerably over 1,000 ft. per minute piston speed with maximum efficiency. With this end in view engines have been constructed with a variety of different forms of valves, as will be shown later; the admission of the charge in some cases being controlled by double and treble valves for each cylinder, and in others by annular and double-seated valves, and so on, and the exhaust by double ported valves, and in the two-cycle engine by wide ports directly controlled by the motor-piston.

In the construction and working of the high speed automobile engine great difference of opinion has existed as to the relative values of automatically operated versus the mechanically or cam opened admission valve. The drawback to the atmospherically opened spring-closed valve is in the restricted lift permitted, this being in practice very little over one-eighth its diameter, and more often less; in working there is an appreciable hang back or delay in both the moment of opening and closing, the piston having to traverse sufficiently to cause a vacuum of 3 or 4 lbs. before the valve opens, and again before the valve can close some of the mixture escapes back. It is in the attempt to combine the advantages of both methods that valves of the type shown by Fig. 2, have been devised. In this manner the valve is permitted to open before the

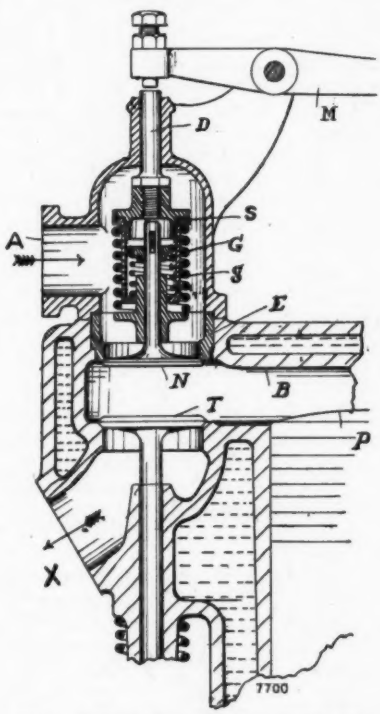


FIG. 2.—"RENAULT" COMBINED AUTOMATIC AND M. O. ADMISSION AND EXHAUST VALVES.

timing of the cam, and to close later if the particular speed of the engine should at any time demand it; at the same time and during the period when the motor piston is travelling at its greatest velocity the valve is pressed open for more than one-fourth of its diameter, so giving more than double the opening that could be conveniently obtained by automatic means alone.

In the illustration (Fig. 2), *A* is the

mixture pipe, *X* the exhaust-pipe, *N* the admission valve, *T* the exhaust valve, *B* the combustion-chamber, *P* the piston; *g* is a light spring on the valve stem, and *G* is a stiffer spring which presses against the cam *S* at the end of the push-rod *D*, which is operated by the cam lever *M*. The valve seat *E* forms a guide for the valve stem, and a stop for the spring *G*, while the weaker spring *g* is held up to the collar on the valve stem by a flanged guide screwed into the push-rod cap *S*; by this means the action of the two springs are independent of one another. Other variations on this principle are the "Peugeot" and "Philips" designs of combined mechanical and atmospherically opened admission valves, and timed to open and close independently of the cam action, so adapting itself automatically to the varying condition of speed and throttle opening of the motor.

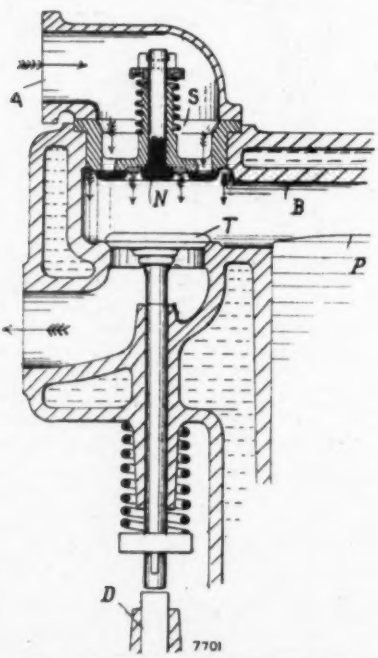


FIG. 3.—"NAPIER" ANNULAR ADMISSION AND EXHAUST VALVES.

The tendency now is gaining ground more and more to dispense with the automatic method with its finely adjusted spring, and to rely altogether on the timing of the opening and closing by a cam, which is formed to keep the valve open during about 200 degrees of the crank-circle. This simplifies the adjustment and permits the use of a spring strong enough to always close the valve at the precise moment determined by the cam at all speeds of the motor.

In several cases the extent of the opening can be regulated by hand to suit the required speed, and as the duration of the opening remains constant this improved method is accountable in a great measure for the even running of many motors so arranged at quite slow speeds.

In order to obtain an increased opening with the small degree of lift permitted in a suction opened valve, the device shown by Fig. 3 has been used. In this annular admission valve an inner seat and portway is provided in both valve and seat. In the "Napier" valve, the centre is thus partly supported against the pressure caused by the explosions by the bearing around the stem. The openings in the valve provide for an increased opening of about 25 per cent., and as this construction permits of an increased diameter the total opening obtained in this way with the small lift permitted approaches to nearly double that of an ordinary sized atmospheric admission valve. Referring to the illustrations and other following sections, *A* denotes the mixture supply inlet, *X* the exhaust outlet, *T* the exhaust-valve, *N* the admission-valve, *B* the combustion chambers, and *P* the motor-piston. In Fig. 3 the admission-valve is held up to its seat by the spring *S*, the lift being limited by the collar on the end of the valve stem to about 3 millimetres; the exhaust-valve, as in most engines of this type, is opened by a push-rod *D* direct from a cam-shaft running alongside the motor, and usually encased by the crank-chamber.

In the "Mercèdes" device shown in

Fig. 4, there is a multiple seat and triple port opening to the cylinder, a design, it will be seen, which is a modification on the lines followed in the "Napier" valve. In this case, however, a still larger diameter of valve is used with annular port openings as in Fig. 3, which rests on a seat with a grid arrangement of port openings forming two circles in place of one as used in the "Napier" valve. A great measure of success has been obtained by this form of valve in high-power racing motors, the larger diameter permitted giving a much freer opening; and requiring a less sensitive spring than would obtain in a smaller valve.

A third method is used by the Wolseley Motor Co. to obtain increased opening to the ingoing mixture. In motors of this make

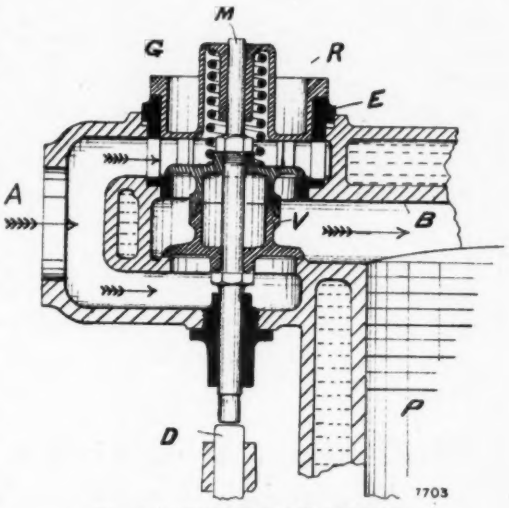


FIG. 5.—"BUTLER" DOUBLE-SEAT ADMISSION VALVE.

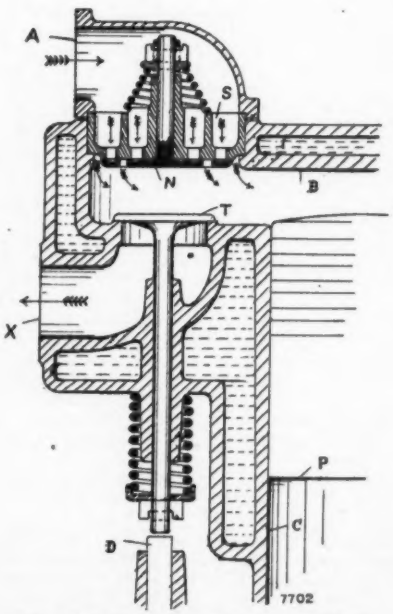


FIG. 4.—"MERCEDES" MULTIPLEX ADMISSION AND EXHAUST VALVES.

of large power, two, and in some cases three inlet valves are arranged in a cluster, their several stems being connected to open and close together; each valve is, however, to some extent, independent of its fellows in being capable of keeping gas-tight on its seat. In using three smaller valves in this manner a larger opening can be obtained than by one ordinary valve, and as the smaller diameters permit of reduced weight and thickness, a quicker action with less drag is obtained.

To meet the requirements of a very free opening in engines of high power and speed, the double seat valve shown by Fig. 5 has been designed. In this case the valve and seating is entirely duplicated, and each valve balances the other, so relieving the pressure on the cam for opening it at the end of the working stroke when the pressure in the cylinder is frequently as high as 40 lbs. per sq. in. This form of valve and seating is capable of giving twice the opening as a single valve of ordinary form, and is made in two separate parts strung on the stem *M*; the bottom disc rests on a seat forming

part of the cylinder casting, and the upper disc forms a gastight fit on the seat *E*; mixture enters at *A*, and is admitted above and below the valve along the U-shaped passage *A*. The cover *R* is not exposed to the pressure of the explosions and serves to enclose the retaining spring *G*. In order to remove the valve quickly for examination at any time, the seat *E* is taken out, when the valve can be inspected and removed if required. The advantage of a double valve is reduced friction on the cam mechanism, and greater opening with less lift than can be obtained by an ordinary mechanically opened valve. In motors used for automobile purposes where very high speeds are used, any diminution of noise, wear and rattle caused by the valves and mechanism in the multiple cylinder motors is of as much importance as the higher power efficiency obtained, so that the slightly higher cost of construction of this form of valve must be discounted to a large extent.

(*To be continued.*)

Results of Recent Experience in the Bacterial Treatment of Sewage.

By W. H. MAXWELL, A.M.Inst.C.E.

(*Continued from Page 116, Vol. 15.*)

The Initiative of Local Authorities in the solution of problems of Sewage Disposal.—Were it not for the commendable initiative taken by local authorities in carrying on original research work on a practical scale in regard to the disposal of sewage—to say nothing of other branches of their work—little or no real progress in this direction could be recorded to-day. But what are the facts? Many of our largest public bodies have availed themselves of the trained assistance of leading experts in the solution of the sewage disposal problem. Their work has been upon entirely original lines; they have sought to solve for themselves questions with which they have long been faced with a practical sternness; they have had no regard for rules and precedent, and expenses have been met out of revenue. The work has been undertaken with a serious earnestness, and advantage has been taken of the latest advances in allied branches of scientific research, with the result that much valuable experience has been gained in regard to the practical application of a new principle which, when rightly applied, promises to lead to the complete solution of the hitherto insolvable question of efficient sewage purification. Had some arbitrary statutory requirement prohibited the free performance of this initiative work, the loss to the community would have been incalculable, but, fortunately, local authorities have so far been enabled to lead the way, whilst those whose duty it may be to frame rules must follow in their wake, and build up "general conclusions" from the practical work thus voluntarily accomplished.

Amongst the authorities, foremost in this great national work must be specially mentioned those of London, Sutton, Exeter, Manchester, Leeds, Leicester, Sheffield, and Birmingham, most of which municipalities have placed the practical results of their labours on record in the form of valuable and exhaustive reports on the experimental work carried out.

London.—Experimental and scientific research work of a high order has been carried out on behalf of the London County Council in regard to the bacterial treatment of sewage at the Barking outfall works, and the practical results obtained have been made known in a series of valuable reports, now available in a somewhat abridged but connected form, entitled the "Experimental

Bacterial Treatment of London Sewage," by Professor Frank Clowes, D.Sc., F.I.C., and Dr. A. C. Houston, M.B., D.Sc. This volume, and particularly the bacteriological portion, forms a most valuable addition to the literature on modern sewage purification and the biology of sewage and bacteria-bed effluents.

It will be remembered that upon the first intimation of the possible utility of biological methods as a means of treating sewage, the London County Council at once commenced experimental work to test the capabilities of the principle for dealing with London sewage. First, the chemically treated effluent was experimented upon with encouraging results, and subsequently crude unsettled sewage was passed into the bacteria beds. The latter procedure, though yielding good effluents, soon choked the beds through the excess of suspended matter. Following this experience, the sewage was first passed through a sedimentation tank, the effluent from which was then dealt with on the beds. By this means choking was entirely arrested, although the time of passage of the sewage through the settling tank was only five hours. Similar experience has since been obtained at Sutton and many other places. It was found that the coke bacteria beds showed a loss of capacity, apparently due to the formation of bacterial growths upon the surface of the coke fragments; but, when these growths had fully formed, the almost unchanging capacity remained, equal to about 30 per cent., of the empty space which had been filled with coke.

It was further found that if the sediment in the tank was left undisturbed, it underwent considerable reduction in amount, partly by conversion into gaseous matter and partly by being changed into soluble or liquid substances The report above cited states that

"over 60 per cent. of the sediment disappeared in this way, and it was evident that if the mineral road grit had been allowed to settle separately, the percentage reduction of the organic matter by this bacterial resolution would have been much greater."

As the result of the experimental work done, Dr. Clowes concluded that

"by suitable continuous undisturbed sedimentation the raw sewage is deprived of matter which would choke the coke-beds, and the sludge which settles out is reduced in amount by bacterial action to a very considerable extent. This reduction might undoubtedly be increased by the preliminary removal of road detritus. The coke-beds, after they have developed their full purifying power by use, have an average sewage capacity of about 30 per cent. of the whole space which has been filled with coke. The sewage capacity of the coke-bed, when the bed is fed with settled sewage, fluctuates slightly, but undergoes no permanent reduction. The bed does not choke, and its purifying power undergoes steady improvement for some time. Coke of suitable quality does not disintegrate during use. The 'bacterial effluent' of settled sewage from the coke-bed does not undergo offensive putrefaction at all even in summer heat, and can never become offensive. This effluent satisfactorily supports the respiration of fish. The use of chemicals is quite unnecessary under any circumstances when the above method of treatment is adopted."

The bacteriological aspect of the question was investigated by Dr. A. C. Houston, who instituted an enquiry extending over some two years, and as a result was able to place on record much original information in regard to the condition of bacteria-bed effluents, and the corresponding samples of raw sewage as well as upon the whole question generally. The work thus accomplished is of the greater value, inasmuch as, notwithstanding the existence of many reports on the bacteriology of crude sewage, at the time when the enquiry was commenced, hardly anything was known of the biological composition of effluents from bacteria-beds or of the methods of measuring the biological *status* of an effluent in its possible relation to disease. Obviously it was of vital importance from a public health point of view to determine how far sewage became modified in its biological characters as the result of its treatment in bacteria-beds, and in this connection it is of importance to note that, notwithstanding the large amount of purification effected in respect of the chemical character of the effluent, one result of the investigation was to

"afford presumptive evidence of a strong kind that the effluents from bacteria-beds cannot reasonably be considered as much, if at all, more safe (bacteriologically) in their possible relation to disease than crude sewage. Beyond question, this portion of the enquiry was of primary and pressing importance, and the results obtained can only be interpreted as meaning that, until reliable evidence to the contrary is forthcoming the effluents from bacteria-beds ought to be regarded as nearly, if not quite, as unfit to be discharged into *drinking-water* streams as would be the sewage before treatment."

The investigation also draws attention to the wide distinction between the biological composition on the one hand, of sewage and of sewage effluents, and on the other of waters of potable sort.

Generally, on the whole question, Dr. Houston concludes, amongst other things, that

"the effluent from the existing works (chemical treatment at Barking and Crossness) are, in a

bacterial sense, grossly impure, and, indeed, the samples examined resembled in their biological composition the raw sewage before treatment. The bacterial coke-beds effect a reduction of at least 50, and it may be as much as 80 per cent. in the amount of dissolved oxidisable and putrescible organic matter in the raw sewage as compared with 17 per cent. effected by the chemical treatment. The effluents from the coke-beds are apparently non-putrescible. The suspended matters in the crude sewage are practically entirely removed as a result of the biological treatment, instead of only about 80 per cent. effected by the chemical treatment. And recent experiments seem to show that this result may be obtained without serious progressive loss of capacity in the coke-beds, if the sewage, before its application to the coke-bed, has undergone a previous process of rapid sedimentation. In the biographical treatment no chemicals are required, and less offensive sludge is produced. Where an effluent is turned into a stream to be used for drinking purposes, the bacteriological results are manifestly of more importance than the chemical; but when, as in the present case, the river is not a potable one, and is already polluted, the converse probably holds good, *i.e.*, the chemical state of the effluent is of primary, and the biological of secondary importance. In the first case, the chief object is to guard against disease, and in the second case the fouling the river with putrescible matters to such an extent as to constitute a nuisance has to be avoided. However desirable it may be to obtain an effluent chemically pure, and at the same time bacteriologically above suspicion of danger, (a) leads to the solution of some of the suspended matters in the raw sewage, (b) effects a striking reduction in the amount of putrescible matters, (c) avoids the use of chemicals and the accumulation of offensive sludge, (d) yields an apparently non-putrescible effluent, and (e) is at the same time practicable, is one which, in that it produces such satisfactory results in view of all the requirements of the case, presents such decided advantages over chemical treatment that it would be idle, merely because it falls short of a standard of perfection, to deny the value or to attempt to minimise the usefulness of the process."

It was found that the effluent from the chemical treatment was seemingly worse bacteriologically than the effluent from the bacteria-beds and much more impure chemically, and, taking into account all the considerations affecting the question, Dr. Houston was of opinion that the gradual adoption of the bacterial treatment of sewage in place of the existing chemical treatment was a practicable measure to be recommended, and would lead to a progressive improvement in the condition of the lower Thames.

Manchester.—Any doubts entertained as to the successful treatment of London sewage upon the bacterial system may be allayed by a consideration of what is now being done at Manchester in this direction upon a large scale. The inadequacy of the process of chemical treatment as carried on at the Davyhulme Works (Manchester) is a matter of common knowledge owing to the effluent, as is usual with precipitation works, containing a large amount of putrescible organic matter, thereby adding considerably to the pollution of the Ship Canal and giving rise to much complaint from the Mersey and Irwell Joint Committee. These chemical works only came into operation in the spring of 1894, but it nevertheless became necessary in May, 1898, to engage three eminent experts to investigate the question of the disposal of the sewage more particularly with regard to bacterial methods of disposal. These gentlemen reported, as is well known, in October, 1899, strongly in favour of the bacterial system for the purification of the sewage of Manchester.

As a result of the large amount of experimental work which has been carried on at the Manchester works, the following leading general conclusions have been reached, and upon which the large new bacterial works, now well advanced, have been based. In regard to the work of the *septic tank*, it was found that

"the effluents from closed and open septic tanks are practically identical in composition. With a tank space equal to half the daily flow it is possible to digest about 25 per cent. of the total suspended matter in the sewage. The suspended matter in the septic tank effluent is of a granular character, and readily separates out on standing, and when arrested on the surface of a bacteria bed does not seriously impede the free flow of the water into the bed. The organic matter in solution is much more easily nitrified than that present in fresh sewage, so that it is possible with one contact to constantly obtain non-putrefactive filtrates. The blending which takes place in the septic tank is of value in minimising the effect of excessive amounts of manufacturing refuse, and in producing an effluent of fairly constant composition."

In the *contact beds* it was found that the chief losses of capacity were due to settling together of the material, growth of organisms, impaired drainage, insoluble matter entering the bed, and the breaking down of the material.

Some very interesting experience is recorded* as to the growth of organisms within the beds:—

"This is at once the cause of increased efficiency in the bed and of loss of capacity. On examining the material of a contact bed in active condition, every piece is seen to be coated over with a slimy growth. If this is removed it soon dries to a stiff jelly, which can be cut with a knife. Under the microscope, masses of bacteria and zoogloea will be found to be present. If placed in a tube containing air, and connected with a manometer, the

* "The Treatment of Manchester Sewage," by G. J. Fowler, Superintendent and Chemist, Davyhulme. July, 1902.

jelly will rapidly absorb all the oxygen and produce carbon dioxide. This action will sometimes produce a vacuum of several inches of mercury. There is little need, therefore, to force air into a bed, as the natural interchange of gases which take place is sufficient for adequate aëration. As a matter of fact, there is always a large amount of oxygen to be found at the bottom of a bed in good condition. The behaviour of the bacterial jelly appears to afford the clue to the successful working of bacteria beds. By working them at a high speed—*i.e.*, filling them frequently in the day without long periods of rest—the effluent may remain good, but the bacterial growth so rapidly increases that the bed becomes too spongy, and will not allow the water to drain away. Here, too, is the explanation of the fact that, within limits, decrease of capacity is accompanied by increase of efficiency. This decrease of capacity may, however, become so great as to outweigh the advantage of increased efficiency. A long period—say one or two weeks' rest—must then be given to the bed. The superfluous bacterial growths will during this time be rapidly consumed, and the capacity of the bed will greatly increase. These rests should not exceed a fortnight at most, as the bed then tends to dry up and the activity of the organisms diminishes."

The new scheme of works for the bacterial treatment of the sewage on a large scale was sanctioned by the Corporation in the year 1900, and comprise five additional tanks similar to the existing precipitation tanks at Davyhulme, 46 acres of first contact bacteria beds in 92 beds of half an acre each at Davyhulme, 26 acres of storm-water filter beds at Davyhulme, a conduit for the conveyance of the first contact effluent from Davyhulme to Flixton, where the area of second contact beds is 46 acres. The scheme is designed to deal with a maximum rate of flow equal to 126 million gallons per 24 hours, the flow up to 63 million gallons being treated by double contact on the bacteria beds, and the subsequent 63 million gallons on the 26 acres of storm-water filter beds. The excess of storm flow beyond the maximum named will be passed into the Manchester Ship Canal.

The bacteria beds are composed of screened furnace clinkers of an average depth of 3 ft. 4 in. The under-drainage is arranged in a radial form converging to a main collecting drain, and consists of channels formed in the concrete bottom of the bed covered with stoneware perforated slabs, set in rebates, flush with the surface of the bottom. The storm-water beds are designed to deal with a flow at the rate of 500 gallons per square yard per day, and the general area of each filter is about 1 acre. The beds are fitted with unscreened clinkers 2 ft. 6 in. in depth, the coarser material being placed over the under-drains and the surface of the bottom. These beds are being used as contact beds for the purification of chemical tank effluent or for the treatment of storm-water by continuous filtration. The floor of the beds is the natural ground surface, which is generally a clayey marl, covered with a layer of cement concrete where the character of the ground renders it necessary. The object of lightly working the beds during dry weather is that they may be stored with nitrates, and thus be maintained in a condition to be worked at an accelerated rate for a short period taking the first flush. When the sewage has become highly dilute it is purified by settlement, followed by *continuous filtration* through the storm beds.

The bacterial works at Davyhulme are now in an advanced stage, and deal with the greater part of the flow, so that the chemical treatment will shortly be abandoned. The control of the storm beds is in the hands of two men who also attend to the light harrowing of the surface which is required not oftener than once a month. The necessity for this operation naturally depends upon the rate at which the beds will pass the water and the character of the filtrate as shown by analysis. Should the top of the bed become sodden, the purification falls off, and it becomes necessary to rest the bed and loosen the surface. Examination of the clinkers of the oldest beds a few inches below the surface shows this material to be quite sharp and clean.

The results of working these beds show that it is possible to satisfactorily deal with very large quantities of storm-water by this means.

From recent experimental work done, it is concluded* that it is not possible to satisfactorily purify Manchester septic tank effluent by continuous filtration through any reasonable depth of *coarse* material, but that satisfactory results are obtainable through a fairly fine medium. With material of the same grade and depth, little (if any) difference is observed between the filtrate obtained by continuous or by contact treatment. Practically identical filtrates are obtained by continuous filtration, whether the distribution is effected by a specially designed stationary distributor or by a layer of fine material.

* Annual Report, Rivers Department of the City of Manchester (year ending March 30th, 1904).

(To be concluded.)

The Ventilation of Tunnels.*

By CHARLES S. CHURCHILL.

In 1904 the writer presented to the International Engineering Congress, Paper No. 43, on the "Ventilation of Tunnels."† Since that date improvements have been made in some of the tunnels and subways referred to, which are worthy of note, and the writer has obtained certain additional data, as to the condition of the air in some subways and tunnels in Europe, which are valuable for comparison in determining good practice.

Gallitzin Tunnel.—The ventilating plant at Gallitzin Tunnel, west of Altoona, on the main line of the Pennsylvania Railroad, was referred to in that discussion as being of the same type as that of the Elkhorn Tunnel, on the Norfolk and Western Railway, and as being practically completed at the date of the discussion.

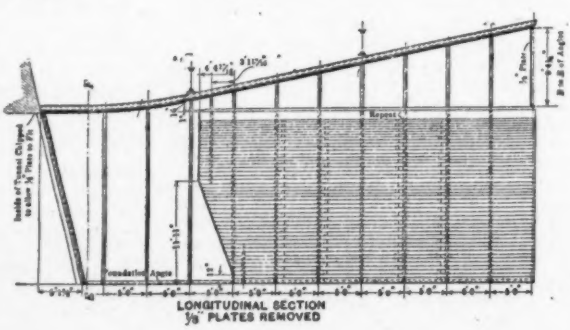
This ventilated tunnel is 3,600 ft. long, and is built for a single track, being 17 ft. wide and 20 ft. 5 in. high, and is lined with concrete. Its sectional area is 324 sq. ft., and the cubical contents of the whole tunnel are 1,166,400 cub. ft. There is an ascending grade of 0·5 per cent. from the east end through the tunnel, but the east approach is on a heavier grade, so that west-bound goods trains generally have a pusher engine at the rear of each in passing through the tunnel.

Fig. 1 shows the general arrangement of the ventilating plant and all important details, its location being at the east or lower end of the tunnel.

With fans making 145 rev. per min. the observed flow of fresh air through this tunnel from east to west is at a velocity of 1,780 lin. ft. per min., equivalent to 576,000 cub. ft. per min. As usually operated, these fans make 130 rev. per min. while goods trains are in the tunnel, and the velocity of the air in the tunnel is 1,550 ft. per min., which results in 502,000 cub. ft. of fresh air being delivered through the tunnel each minute. With the fans running at this speed, the tunnel is cleared directly after the exit of a west-bound train. Excepting when goods trains are in the tunnel, the fans run at from 40 to 60 rev. per min.

There are, as shown by Fig. 1, two 8 by 16-ft. fans, one on each side of the track, each operated by a direct-coupled engine of about 200 h.-p., the total rated horse-power of the plant being 400. This ventilating device was put into regular operation in April, 1905.

Simplon Tunnel.—This tunnel, which



* Proc. Am. Soc. C.E., Vol. xxxii., p. 440, presented September 19th, 1906.

† Published, with articles by other writers on this subject, in *Transactions*, Am. Soc. C.E., Vol. liv., Part C., pp. 523—579.

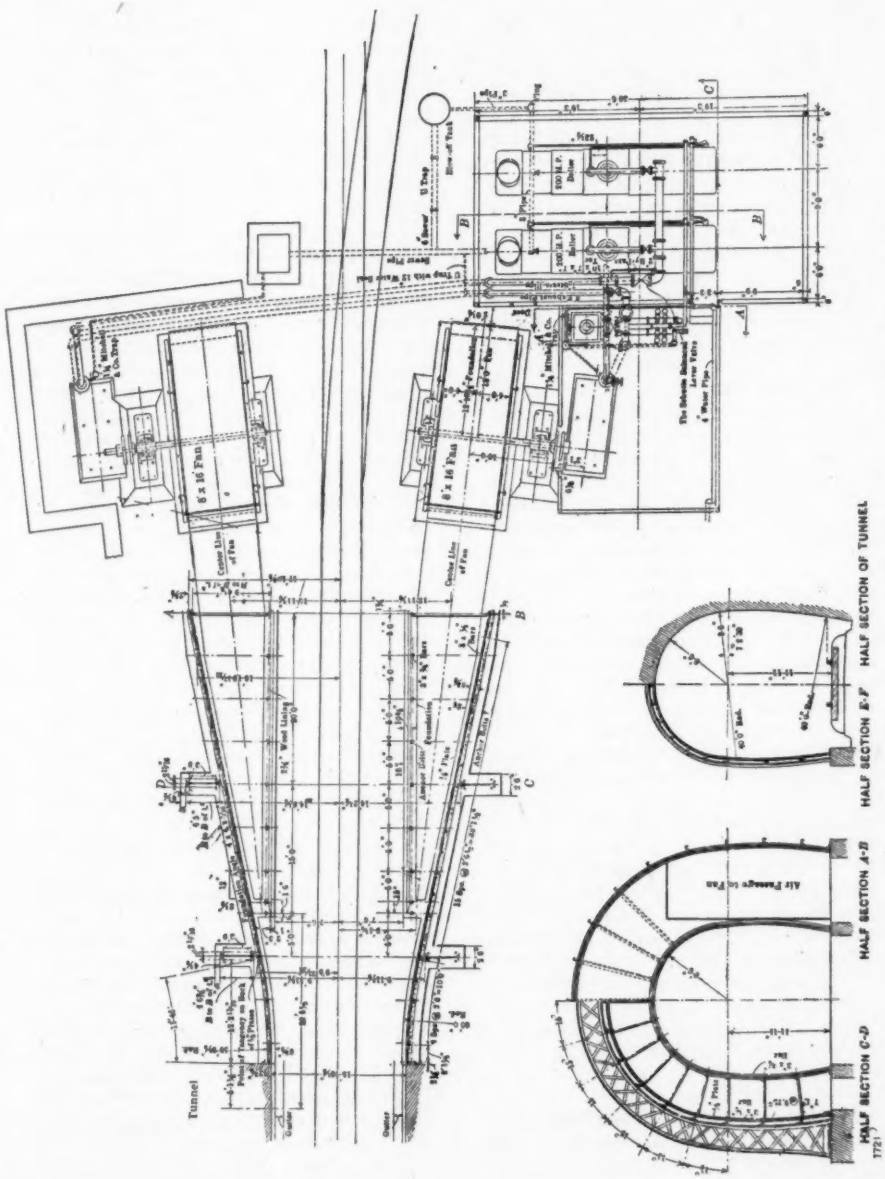


FIG. 1.—GENERAL PLAN OF VENTILATING PLANT AT THE GALLITZIN TUNNEL, PENNSYLVANIA RAILROAD.

is 12·33 miles long, and is constructed for a single track, with one passing siding at the centre, was completed early in 1906, and was formally opened on May 19th, 1906. The ventilating plants used during construction are described in *Transactions*.*

When the writer visited this tunnel, in the summer of 1905, a steel sliding door at each portal was arranged so as to be raised and lowered by electric power. The plan at that time was to lower the steel door after the entrance of a train and to force fresh air from the fans at that end of the tunnel into and through the tunnel with considerable pressure.

The adoption of electricity as the power for handling trains through this tunnel has greatly simplified the problem of ventilation.

The St. Gothard Railway Tunnel.—This steam-railroad tunnel is 9·3 miles long, is located on light grades, and is double-tracked. It has a large section, the area being 603 sq. ft., or approximately 3·2 times the area of two trains occupying the tunnel section. The cars of trains while in the tunnel are lighted by gas.

This tunnel is ventilated by a Saccardo plant, at Goeschenen, at the north end of the tunnel. It consists of two large fans operated by water power. Ventilation is secured by reducing the area of the tunnel section by about 38 per cent. near its northern end.

For comparative purposes, a sample of air was taken by the writer from a car of a north-bound train, running 30 miles per hour, at a point about 3 miles from the south end. The temperature was 82° F., and the air contained 10·19 parts of carbonic acid gas (CO_2) per 10,000 volumes. The measured quantity of fresh air which the writer found to be passing into the north end of the tunnel from the ventilating plant was 413,000 cub. ft. per min. at a velocity of 686 ft. per min.

Special attention is called to the large area of the tunnel section relatively to the cars used, and the consequent small velocity and volume of fresh air used in ventilation. The other favourable condition in this tunnel is the light grade throughout its length, so that the coal consumption of locomotives while in the tunnel is kept low. At the measured velocity of the ventilating air current, a period of 1 hr. and 12 min. is required to change the air in this tunnel.

The Berlin Elevated and Electric Railway.—This electric railway is largely above ground, but there are short sections of subway, having a rectangular section of about 231 sq. ft., in which single span there are two tracks. The stations are roomy, and each is provided with two large stairways leading directly to the surface, thus insuring fair ventilation. The air in these short subway sections was noted by the writer as being good.

Metropolitan Railway, Paris.—The Metropolitan Underground Railway of Paris is a double-tracked arched tunnel, nicely lined, and built as close to the surface of the streets as practicable. It is electrically operated. The stations are comparatively close together, averaging less than 1,700 ft. apart. The two tracks are in one span, the area of the tunnel section being 315 sq. ft. This section is greatly enlarged at each station, thus providing in one span ample room for platforms. The area of the tunnel is approximately twice that of the two trains occupying the tunnel section.

This railway is specially notable for the large tunnel section, roomy stations at short distances apart, and the provision of two large stairways at each station, giving good direct outlets for ventilation. Two short portions of two lines of this road were examined by the writer. A sample of air taken at 7·40 o'clock on a bright morning, from a Metropolitan Railway car, between Palais Royal and Alma Stations (between which there were five stops at intermediate stations), temperature 70° F., contained 2·94 parts carbonic acid gas per 10,000 volumes of air, the outside air at that time containing 1·76 parts.

The Mersey Tunnel, Liverpool.—This

* *Transactions*, Am. Soc. C.E., Vol. liv., Part C., p. 531.

tunnel is 2 miles long, has a section of about 425 sq. ft., and is provided with two tracks. It is now electrically operated, and is well ventilated by large fans.* The air in this tunnel is now good. A sample taken by the writer from a car in this tunnel, July 24th, 1905, contained 4·70 parts of carbonic acid gas per 10,000 volumes.

The District Railway, London. — The District Railway is a double-tracked subway, with its grade level generally as close as practicable to the streets above it, and with frequent openings to the surface, in addition to having stations approximately half a mile apart. It was formerly operated by steam, but has now been electrified, primarily to secure better ventilation.

For comparative purposes, the writer quotes a test, made in 1902 for the London County Council, which showed that the air in a car contained 15·1 parts of carbonic acid gas per 10,000 volumes. A sample of air taken from a District Railway car by the writer, between Mansion House and Temple Stations, on a fair day, June 27th, 1905, at 4.25 p.m., temperature 76°, contained 11·27 parts of carbonic acid gas per 10·000 volumes, the outside air at that time containing 3.55 parts.

Metropolitan Railway, London. — The Metropolitan Railway is similar to the District Railway in construction and operation, and has also been electrified, for the same reasons.

A test made in 1902 for the London County Council showed that the air in a car on this road contained 28·8 parts of carbonic acid gas per 10,000 volumes. A sample of air taken from a Metropolitan Railway car by the writer, between Gower Street and Portland Road Stations, on a very clear day, July 24th, 1905, at 12.40 p.m., temperature 74°, contained 14·07 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing only 1·75 parts.

City and South London Railway.—This electrically operated line extends from the "Angel" to Clapham Road, about 6 miles, with 13 stations on the entire line, the average distance apart being half a mile. It consists of two single-track tubes, the inside diameter of each being 10 ft. 6 in. They are deep below the surface of the ground. As these tubes are small, the clearance around the trains is very narrow. The tubes are connected by small passages at the stations and by cross-overs near a few of them. The area of each tube is 86 sq. ft., the area of both tubes being, therefore, 172 sq. ft.; and one tunnel section equals about 1·4 times that of a train. The travel on this line is not as heavy as on some others, notably the Central London Railway. It is not ventilated artificially, and the air is not as good as in other tubes of the electric railroads in London. The only natural ventilation is through a stairway and generally three lifts at each station. The stairway has a minimum opening of from 35 to 40 sq. ft. One lift contains about 2,500 cub. ft., and has a capacity of about fifty persons. During ordinary light traffic only one of these lifts is required per train.

The draught produced in the tunnel by an approaching train lasts only one minute, and amounts to only about 17,000 cub. ft. The draught that follows a train lasts about half a minute, and amounts to only about 8,000 cub. ft. At the stairway of Borough Station, at the time of the passage of a train, a downdraught was noted for one minute, equal to about 7,000 cub. ft. of air, followed by an up-draught for half a minute, amounting to about 2,000 cub. ft. of air. In addition to this, each lift removes in its upward passage about 2,500 cub. ft. of air. This quantity per station is clearly insufficient to balance the vitiation of the air by the occupants of a train.

Tests made in 1902 for the London County Council showed that there were 14·2 parts of carbonic acid gas per 10,000 volumes of air in an empty carriage. A sample of air taken from a City and South London car by the writer, between

* A detailed description may be found in the papers on the Ventilation of Tunnels, International Engineering Congress, St. Louis, 1904, *Transactions*, Am. Soc. C.E., Vol. liv., Part C., pp. 527—558.

London Bridge and Moorgate Stations, on a fair day, June 27th, 1905, at 3.45 p.m., temperature 74° F., contained 11·78 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing 3·55 parts.

Another sample, taken on July 24th, 1905, from a car of the same road between Elephant and Castle Station and London Bridge Station on a still brighter day, at 9.25 a.m., temperature 69° F., contained 8·69 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing only 1·75 parts.

The sample taken in June shows that the car air contained a little more than three times the quantity of carbonic acid gas found in the outside air on that day, while the sample taken on July 24th, though lower in this gas, contained nearly five times the quantity found in the fine outside air on that day, and actually seemed to the sense fully as poor in quality as that taken in June.

Central London Railway.—This electrically operated line extends from Shepherd's Bush to the Bank, about 6 miles, with thirteen stations in this distance, averaging half a mile apart. It consists of two single-track tubes, each 11 ft. 6 in., minimum inside diameter, connected by passages at the stations, also by six cross-overs in the entire length. The area of each tube is 100 sq. ft., the area of both tubes being 200 sq. ft. The cubical contents of the entire railroad tubes are equal to about 6¼ million cub. ft.

The natural ventilation is by a narrow stairway and about three lifts at each station. Mechanical ventilation of the tunnels is secured by a fan at Shepherd's Bush Station, which draws in fresh air from the opposite end of the line—that is, Bank Station, and other stations at intermediate points. The fan is 5 ft. wide, 20 ft. in diameter, and makes 145 rev. per minute. It is operated by electricity, and is rated at 300 h.p. Its capacity is 100,000 cub. ft. per minute. It is operated from 1 to 4 a.m. (3 hours), with the outlet doors at all intermediate stations shut, therefore it draws in fresh air from Bank Station. During the operation of the fan, the water-gauge pressure in the tunnel is 4½ in., and the linear velocity of the air in the tunnel is 500 ft. per minute. The fan is also operated during each day from 11 a.m. to 5.30 p.m., or 4½ hours, all the doors of the passage-ways at the stations being open. This improves the air in the tunnels for about one-half the length of the line—that is, for the 3 miles nearest to Shepherd's Bush Station; it also clears out the cars as they come to this last station.

The result of night pumping, as indicated by an anemometer placed in the tunnels at the Post Office Station (the first one west of Bank Station), shows that each week an average of 123·9 million cub. ft. of fresh air entered during the night pumpings, which is equivalent to 17·7 million cub. ft. per night. As the tunnels contain 6¼ million cub. ft., they are cleared about 2¾ times each night.

The result of this night ventilation is shown by tests taken on February 15th, 1905, at the Marble Arch Station cross-over siding, which is about half way between Shepherd's Bush and Bank Stations. At 9.30 p.m. the air was found to contain 10·3 parts of carbonic acid gas per 10,000 volumes. The fan was started at 1.37 a.m., and at 2.15 a.m. the air at the same point contained only 3·7 parts, which was the same as that in the outside air.

The amount of natural ventilation procurable is shown by some other tests made during the same night. Between 9.30 p.m. and 1 a.m. (3½ hours), the air in the tunnel had cleared slowly from 10·3 parts to 6·0 parts of carbonic acid gas per 10,000 volumes at the latter time. During these tests the temperature of the tunnels was 66½° F. Another test, taken on February 2nd, 1905, with the fans not running, and when the outside air contained 4·4 parts of carbonic acid per 10,000 volumes, showed that the tunnel air averaged 7·07 parts of carbonic acid gas, while the air in a full car contained 10·7 parts.

The methods now adopted for ventilating the Central London Railway have been put into force since 1902, and the question of adding to this ventilating system is now being considered.

The first ventilating plant on this road was at Bond Street Station, but it has not been used since the installation of the present ventilating plant at Shepherd's Bush.

A long series of tests made in 1902 for the London County Council showed that the air in the cars contained a minimum of 9·60 parts of carbonic acid gas per 10,000 volumes, at a time when the outside air contained 3·30 parts, and a maximum of 14·7 parts of carbonic acid gas per 10,000 volumes, when the outside air contained 3·30 parts.

A sample of the air taken from a Central London Railway car by the writer, between Chancery Lane and Post Office Stations, on a fair day, June 27th, 1905, at 1.55 p.m., temperature 76° F., contained 5·92 parts of carbonic acid gas per 10,000 volumes, at a time when the outside air contained 3·55 parts.

Another sample taken by the writer on July 24th, 1905, from a car on the same road, between Tottenham Court Road and Oxford Circus Stations, on a still brighter day, at 1 p.m., temperature 72½° F., contained 7·04 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing only 1·75 parts.

Great Northern and City Railway, London.—The Great Northern and City Railway extends from Moorgate Station to Finsbury Park, a distance of 3·43 miles. It is electrically operated and lighted, and there are six stations, varying from 2,000 to 6,200 ft. apart. Drayton Park Station, which is 4,200 ft. south of the northern terminus, is all in the open for 600 ft., therefore the main tunnel on this road extends from Drayton Park to Moorgate, a distance of 2·62 miles; the longest distance between stations being from Essex Road to Old Street, 6,200 ft. This line was put into operation in 1904, and is in many respects the best one examined by the writer. It consists of two single-track tubes, each 16 ft. inside diameter, connected by five small cross-passages at each of the station platforms, in addition to some cross-overs. The station platforms are generally 420 ft. long, to accommodate a standard train of seven coaches each 50 ft. long, carrying a total of 430 passengers. The special features of this subway are its large tubes and the large stairways and passage-ways, as compared with other London subways. Each of these items is claimed by the officials of the road to be a direct benefit in ventilation. The line is expected to handle 27,000,000 passengers per annum. The maximum train service arranged for is 3 minute spacing, making 3½ miles in 13½ minutes, including 20 seconds for each of four intermediate stops.

The area of each tube is 190 sq. ft., the area of the two tubes being 380 sq. ft. The area of the tunnel, therefore, is about 1·8 times that of the large cars of the trains therein. The approximate cubical contents from the open end at Drayton Park to the closed end at Moorgate Station is 5½ million cub. ft.

Its natural ventilation is by two stairway passages at each station, the minimum area of each passage being 57 sq. ft., or a total of 114 sq. ft., in addition to that furnished by three lifts at every station, each having a floor area of 130 sq. ft., or cubical contents of about 1,500 cub. ft.

Its artificial ventilation, applied since the line was opened, is obtained by a fan, having a diameter of about 6 ft., located at Pool Street, which is 6,330 ft. from the Moorgate end of the tubes. This fan has a capacity of 1,000,000 cub. ft. of air per hour, and, as operated, forces fresh air through a heading 10 ft. in diameter into the up-tunnel—that is, toward Moorgate Station, in the direction of travel. A large part of this current travels to Moorgate Station cross-over and then into the down-tube. The present practice is to operate this fan twice each day, during the busiest periods, from about 8 to 10 a.m., and from 5 to 8 p.m., so that a volume of

fresh air practically equal to the cubical contents of the entire subway is forced into it each 24 hours.

As to natural ventilation: Measurements of the currents in the stairways on the arrival and departure of trains show approximately a total of down-currents for each train per station of 20,000 cub. ft., and about the same for up-currents. The total ventilation per train for each direction, therefore, amounts to about 90,000 cub. ft. On a 5 minute spacing of trains, each filled with 430 persons, the change of air per hour amounts to 1,080,000 cub. ft. in the entire subway, or 18,000 cub. ft. per minute. However, as there are constantly four trains in the tubes carrying a maximum of 1,720 people, and as each person requires 30 cub. ft. of air per minute, the total requirement is more than 51,000 cub. ft. of fresh air per minute, in order to keep the tunnel air of the same quality as the outside air, or about 26,000 cub. ft. per minute in order not to increase the carbonic acid gas by more than twice the quantity in the outside air. These figures show why ventilation has been found necessary during the busy hours to maintain air of the desired purity even in this excellently constructed subway.

On March 5th, 1904, before ventilation was established, a test of the air in this subway was made by Dr. Critchley, with the following results: The air in the street was found to contain 4·5 parts of carbonic acid gas per 10,000 volumes, that of a car in the subway was found to contain 9·0 parts, the temperature being 61½° F.

On February 20th, 1905, Dr. Southerland found that the air on the platform in the subway at Old Street Station contained 4·48 parts of carbonic acid gas per 10,000 volumes, temperature 54° F. while that in a car approaching this station was found to contain 7·22 parts, the temperature being 55½° F.

A sample of air taken from a Great Northern and City Railway car, by the writer, between Highbury and Old Street Stations, on a very bright day, July 24th, 1905, a little after noon, temperature 68° F., contained 2·35 parts of carbonic acid gas per 10,000 volumes, the outside air at that time containing 1·75 parts.

St. Clair Tunnel.—The St. Clair Tunnel, on the Grand Trunk Railway, with its insufficient ventilation, is described in the *Transactions* of the Am. Soc. Civil Engineers.*

On October 9th, 1904, six employees of the railway were killed in this tunnel by gas and smoke from a locomotive while necessarily standing in the tunnel on account of a break-in-two of a train. This accident is fully described in *The Railway and Engineering Review.*†

In lieu of installing a system of ventilation, the Tunnel Company has during this year contracted for the electrical operation of this tunnel by methods described in detail in *Engineering News.*‡

This will remove all danger from such causes, and very greatly reduce the discomfort of persons in the tunnel; but, nevertheless, in the future some means of artificial ventilation may be found desirable, as in the case of the Mersey Tunnel, Liverpool.

Park Avenue Tunnel, New York City.—Park Avenue Tunnel, New York City, on the New York Central and Hudson River Railroad, is described in the *Transactions.*§ The work of providing for electrical operation, which was undertaken partly for the purpose of improving the ventilation, is rapidly progressing, under plans fully described, with official reasons therefor, in *Engineering News.*‖ The reasons given are, briefly: Improvement of ventilation, greater safety in operation, and increased capacity.

The Rapid Transit Railway, New York City.—The subway sections of this railway are either four-tracked, of rectangular cross-section, or of two double-tracked cross-sections. The former is the one used on the busiest part of the line, below Forty-second Street. The

* Vol. liv., Part C., p. 529.
† October 15th, 1904, Vol. xliv., p. 740.
‡ January 18th, 1906, Vol. lv., p. 59.
§ *Transactions*, Am. Soc. C. E., Vol. liv., Part C., p. 528.
‖ November 16th, 1905, Vol. liv. p. 499.

stations on this portion average about 1,500 ft. apart. The area of this four-tracked cross-section is about 650 sq. ft. The sectional area of the tunnel therefore is 1·8 times that of the four trains occupying the subway.

This subway is of steel construction, with concrete, and is built quite close to the surface of the streets. The outlets to the street at the stations consist of from two to a maximum of eight stairways, which, while large enough for the people entering the stations, are not as direct as in some of the European subways, and have not a total outlet area as large in proportion to the tunnel cross-section, or to the number of trains and people in the subway at one time.

The writer predicted in 1904 that mechanical ventilation would be found necessary to secure a positive change of air.

On November 21st, 1904, a sample of air was taken from a car in the Rapid Transit Subway, between Forty-second and Twenty-eighth Streets, and one between Spring Street and Astor Place, and these were found to contain too great a percentage of carbonic acid gas. Again, on December 28th, 1905, at 4 p.m., the temperature being 60° F., a sample of air, taken from a car of the Rapid Transit Railway, between Twenty-third Street and Brooklyn Bridge Stations, was found to contain 15·58 parts of carbonic acid gas per 10,000 volumes of air.

The various tests of air made by the writer in London and Paris, have shown that, except in the deeper subways, the air has as high a temperature as that outside. In the Rapid Transit subway, during the summer of 1905, a considerably higher temperature of the air was recorded. This is another reason why it will become very urgent to establish a complete system of mechanical ventilation, for the health of the employees and the comfort of the patrons, as in the case of the subway tunnels in Boston, Liverpool, and London.

Subway Tunnels Generally. — Among the statements heretofore made are included records of the determination of carbonic acid gas (CO_2) in the London subways as well as in their cars. From these data, also from other similar tests of air reported upon by the London County Council, in subway tunnels when they were not fully ventilated, the air found in subway cars contains about 45 per cent. more carbonic acid gas than the average air found in the subway tunnels and stations. Inasmuch as the patrons and a large number of the employees of a subway tunnel line spend most of their time in the cars, the vital fact to be determined, as to the health and comfort of these individuals, is the amount of carbonic acid gas in the cars themselves. Therefore, tests of air in subway tunnels and stations are simply somewhat indicative of the conditions that will be found in the cars. It may be anticipated that the amount of carbonic acid gas in the cars will be at least 45 per cent. more than in the subway tunnel, and in crowded cars the proportion of carbonic acid gas will be still greater.

The writer, therefore, has confined his investigations everywhere to the vital question, namely, the quantity of carbonic acid gas (CO_2) found in the ordinary cars of tunnels, and the tests by him were taken in cars ranging from one-fourth to one-half full. Any reports of the amount of carbonic acid gas found in subway tunnels or stations, therefore, should be increased by about 45 per cent. in order to obtain any fair idea of the conditions met by the passengers and employees themselves; so that, if a subway contains as much as 6·5 parts of carbonic acid gas per 10,000 volumes of air, there will probably be found in the cars 8·4 parts or more.

It has further been shown by detailed measurements of natural ventilating currents in the London subway tunnels, from the smallest to those of the largest section, that an insufficient quantity of air is drawn into them to ventilate all parts of them properly. While the portions having light traffic may at times be free from too large a proportion of carbonic acid gas, those parts

having heavy traffic will contain an excess. The conditions of traffic in the Rapid Transit Railway of New York, for example, are such as to indicate the presence of much more carbonic acid gas in the cars while traversing the lower portions of the subway tunnel than in the remainder.

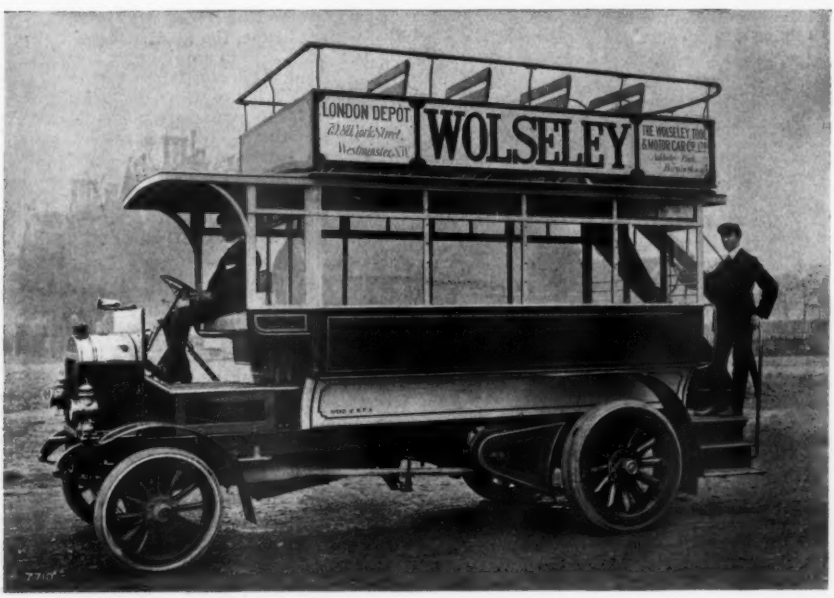
Proper ventilation is not secured unless all parts of a subway tunnel receive a sufficient quantity of fresh air to balance properly the vitiation of that in the cars by the occupants thereof, and this result cannot be secured, as has been shown, except by an efficient system of mechanical ventilation that will distribute fresh cool air everywhere in the cars, as well as in the subway tunnel and its stations.

Standard of Purity for Air.—Much has been written as to what constitutes good air and what is dangerous. The most important test is the determination of the parts of carbonic acid gas (CO_2) in a given sample per 10,000 volumes. Ordinary air varies considerably, during different kinds of weather, from about $1\frac{1}{2}$ parts to more than 4 parts of carbonic acid gas per 10,000 volumes, but the ordinary figure is about 4 parts. The best authorities state that the air in any subway should not contain more than twice the amount of carbonic acid gas found in the outer air (the two being nearly always directly compared), and that, therefore, the general limit is 8 parts of carbonic acid gas per 10,000 volumes. The Factory Act of England makes 9 parts of carbonic acid gas as the maximum in rooms, etc. The report to the London County Council in 1902 places the safe limit at 8 parts, as being the maximum that should exist in the air of subways; and that report states further that the number of bacteria in subway air was generally found to increase and decrease in proportion to the carbonic acid gas in the air. The writer, while investigating this subject in London, during July, 1905, learned that public opinion is very strong in demanding air in subways that shall generally not contain more than 8 parts of carbonic acid gas per 10,000 volumes of air, and that periodical attacks by the Press are made, substantiated by detailed reports of noted chemists, against any subway tunnel where, for a period, air is found to contain more than this quantity of carbonic acid gas. Hence, it may be stated that 8 parts of carbonic acid gas per 10,000 volumes is the maximum proportion of carbonic acid gas that should be allowed in the air of cars in subway tunnels.

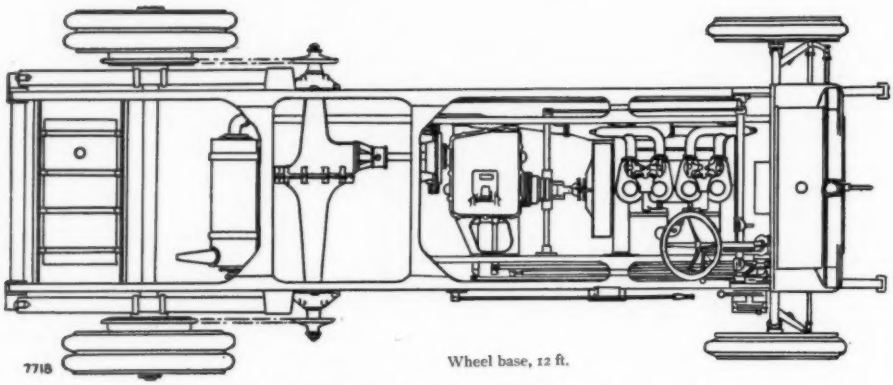
Automobile Engineering.

By ROBERT E. PHILLIPS, M.I.Mech.E., A.M.Inst.C.E.

The New "Wolseley" Four-Cylinder Chassis.—Through the courtesy of the Wolseley Tool and Motor Car Co., Ltd., we are able to illustrate their new four-cylinder chassis for omnibusses, lorries, or heavy vans. This differs materially from their previous practice, as it is fitted with a "Siddeley" engine which has vertically arranged cylinders, and the transmission follows the accepted practice, viz., by propeller shaft to gear box and differential countershaft, and thence by side chains to the road wheels. The frame is of pressed steel of taper channel section, which carries an inner frame for carrying the motor and gear box. The springs are of the semi-elliptic type, the rear ones being 5 ft. long. The rear end of these springs support the rear end of the frame by hangers somewhat after locomotive practice, as will be seen from the illustrations. The length of the frame overall is 16 ft. 10 ins., and the width 3 ft. 10 ins., giving a wheelbase of 12 ft. and a track of 6 ft. 2 ins., the overall width being 7 ft. 2 ins. The front axle is made of Vickers' special axle steel of "I" section, and has its jaw ends forged from the solid. The back axle is tubular, the wheels running on phosphor-bronze bearings. The motor, which develops 30 h.-p. at 900 revolutions per minute and 33 h.-p. at 1,050 revolutions per minute, has four cylinders 4½ in. bore by 5 ins. wide. The crankshaft, which is of Vickers' special crankshaft steel, is carried in three bearings having white metal bushes, the bearings being so arranged that the lower part of the crank chamber can be detached without affecting their alignment. The upper part of the crank chamber is provided with

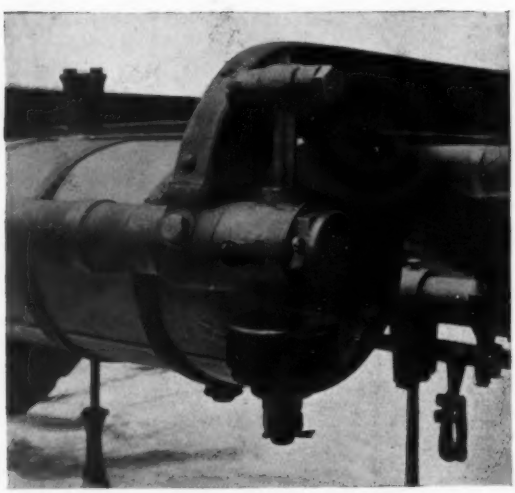


THE NEW "WOLSELEY" FOUR-CYLINDER OMNIBUS.



THE NEW "WOLSELEY" FOUR-CYLINDER CHASSIS: PLAN.

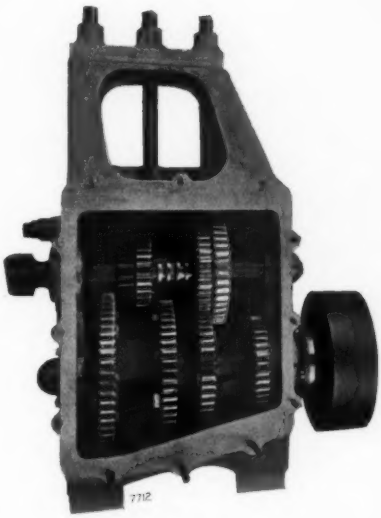
BRAKE ADJUSTMENT.



REAR END OF CHASSIS, SHOWING SPECIAL FORM OF SPRING SUSPENSION.

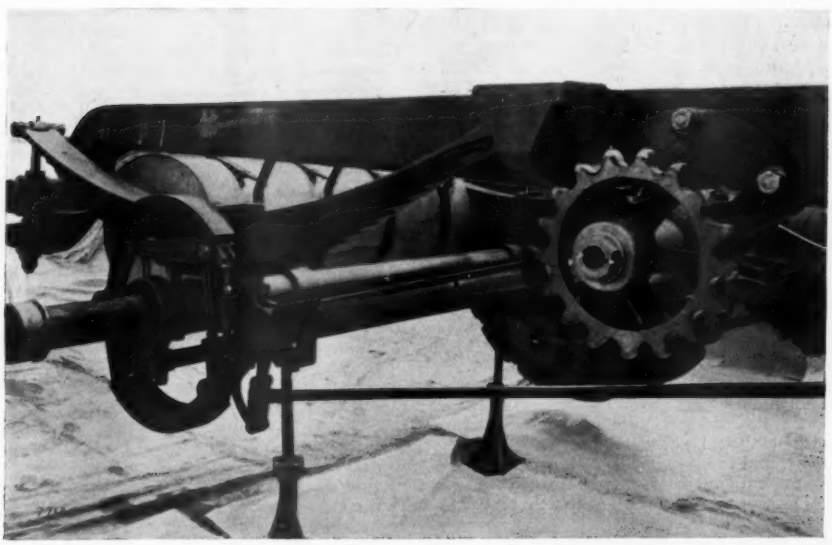
inspection doors. All the valves are mechanically operated, the exhaust valves by direct pushers, and the inlet valves—which are located above the exhaust valves—by pushers operating through overhead rockers. The ignition is by low tension magneto "Simms Bosch." The carburettor is of the compensating type, the feed being under pressure maintained by an automatic valve connected to the exhaust, a hand-pump being fitted to get the necessary pressure for starting. The lubrication supplied is under pressure to all the important bearings by a pump driven by the engine, but the big ends of the connecting rods are lubricated by oil collectors which pick up oil from the bottom of the crank chamber in which the oil is kept at a constant level by means of a gauge. The cooling water is circulated by a centrifugal pump driven from the cam shaft gear wheel, the radiator being of the gilled tube type with surrounding water tank. The clutch is of the coned type, leather faced, with underlying springs to enable the load to be picked up gradually. The counter shaft and the differential gear are carried in a box independent of the change speed gear, connection between the two being effected by means of a short propeller shaft. The

gears are of the sliding type, giving four forward speeds and one reverse, the forward speeds being $3\frac{1}{2}$, 5, 8 and 12 miles per hour with 17 tooth sprockets and an engine speed of 900 revolutions per minute. Two independent brake systems are fitted, the one a double acting hinged metal-to-metal strap and drum of the locomotive type acting on an extension of the second countershaft of the gear box, and the other metal-to-metal expanding shoes engaging drums on the sprocket wheels on the rear road wheels. These latter are double acting, and are balanced on each side. To enable the brakes to be adjusted without the use of tools, railway practice has again been followed, the connecting rods being fitted with screw shackles having operating handles so arranged as to lock the parts against rotation when not in use. The wheels are wooden, of artillery pattern, the rear ones being suitable to receive 4-in. twin rubber tyres, and the front ones $4\frac{1}{2}$-in. single rubber tyres. The total weight of the chassis when fitted with these tyres is 2 tons 18 cwt.

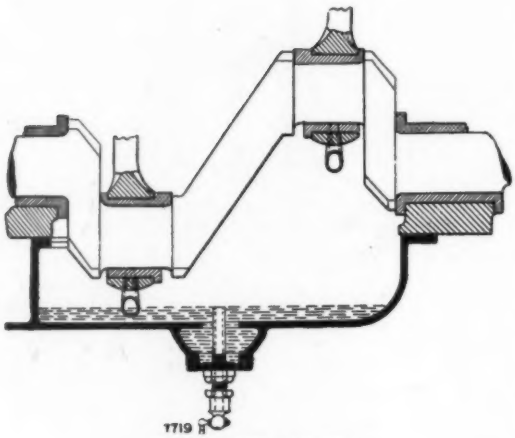


GEAR BOX OPEN.

A Heavy Oil Vaporiser. — The success of the Ivel Agricultural Motor Tractor in this country has created a big demand for these useful machines in the colonies and some foreign countries, and as petroleum spirit is difficult to obtain in some of these places it became necessary to fit the motors with a vaporiser for using



VIEW OF CHASSIS, SHOWING REAR AXLE, ARRANGEMENT OF BRAKE MECHANISM, ETC.



DETAILS OF OIL COLLECTOR.

heavy oils. Not being satisfied with any type already on the market the manufacturers set to work to produce one of their own, which, after a series of long and exhaustive experiments under the most varying and trying conditions, has proved itself quite satisfactory.

The apparatus, as will be seen by the illustration, consists of a chamber intersecting a length of pipe either forming part of or adapted to be introduced into the induction pipe. In this chamber are placed a nest of longitudinally arranged tubes. The exhaust of the engine is arranged to pass through the chamber and the nest of tubes contained therein, the amount passing being controlled by a tap or valve. The one end of the induction pipe is connected with an ordinary spraying or float feed carburettor, so that the oil drawn into the pipe passes around the heated nest of tubes and thereby becomes thoroughly vaporised. To provide for starting the apparatus when petroleum spirit is not available for use until the apparatus is warmed up, an opening is provided into the chamber containing the nest of heating tubes for the insertion of a blow lamp. The whole construction of this apparatus is so simple that it is difficult to see how or why it should get out of order or fail to work, and for this reason alone it appears to be eminently adapted for use in the colonies and other out of the way places.

A New Steam Omnibus.—One of the new "Darracq-Serpollet" steam omnibuses has made its appearance on the London streets, though it does not appear to be yet "in commission." This 'bus, which is the product of the Darracq-Serpollet Co., is the outcome of an amalgamation of the abilities of Monsieur A. Darracq, of motor-car fame, and of Monsieur Serpollet, so well known in connection with steam cars. The whole construction differs so materially from what has hitherto been associated with the name of Serpollet as to be worthy of notice. The engine is now a double acting one with horizontal cylinders having a bore of 85 m/m and a stroke of 120 m/m. The valves, which are of the poppet type, are located above the cylinders, and are operated by a gear-driven cam shaft, placed forward of the crank shaft. All the glands have metallic packing. "Notching up" and reversing are obtained by moving the cam shaft longitudinally so as to give a different angular advance to the cams. All the moving parts are contained in a case which acts as a receptacle for the lubricating oil, the distribution of which to all parts being effected by a mechanically operated pump. The details of the engine are well designed and all the bearings have ample bearing surfaces. The generator, which is of the semi-flash type, consists of a series of units each consisting of a length of tube, shaped so that it forms a series of V-shaped bends. Each length is then so bent that one half of the bends lies at a right-angle to the other half, and thus forms a flat grid. These grids are laid on one another, and the adjacent ends of the tubes are connected by U-shaped coupling pieces. The generator is enclosed in a strong metallic case which can be easily opened up for inspection. The water feed is by a direct acting pump, which is a double one, the other one feeding oil to the burner. This is designed to burn paraffin oil, which passes through a coil located above the flame before it passes to the interior of the burner. The fact that a generator of such limited size is capable of generating sufficient steam for an engine of the size given is remarkable, and points to considerable economy. Two condensers are employed, a small one located at the rear end of the chassis, which first receives the exhaust steam, and a larger one located in front of the generator, which is carried in front of the dashboard in the place where the internal combustion motor is to be found

in most self-propelled carriages. It is interesting to note that two brakes are employed, so that the use of the engine as a brake is not relied on as a compliance with the Local Government Board regulations. Both these brakes are of the internal expanding type, the one operating on the transverse differential shaft, and the other on the back wheels. The frame is of pressed steel, and is strongly stayed, while the springs are of ample dimensions, a *sine qua non* in this type of vehicle.

A New Motor Cab.—Although many types of motor cabs have been placed on the streets of Paris and London they have almost without exception been of the type to replace either the "Victoria" of the Parisian or the "Hansom" of the Londoner. The Argyll Company have recently entered the field of motor-cab construction and produced a cab which may be said to be adapted to take the place of the London "growler," a cab, by the way, most useful though most abused. The general design and appearance of the new cab can be judged by the illustration. Although it has a roomy body, the wheel base is not unduly long by reason of the seat for the driver being placed over the engine. The length of the vehicle overall is 10 ft., and it can be turned completely in less than a 30 ft. circle. The engine employed is the standard pattern 16 h.-p. "Argyll," which has four cylinders, 90 m/m bore and 120 m/m stroke. The transmission is by propeller shaft and live axle. To test the running capabilities of this vehicle one was driven up from Glasgow to London with a full complement of passengers; the total weight of the vehicle with passengers and luggage being 37 cwt., made up as follows:—vehicle 26 cwt., passengers and luggage 11 cwt. Throughout the journey it was only necessary to drop to the second speed twice, and an average speed of 18 miles an hour was made. A novel feature, and one that makes for cleanliness, is that the upholstery of the interior is detachable, so that it can readily be taken out and replaced.

A New Light Van.—One of the new James and Browne 15-cwt. vans has been lately undergoing a particularly satisfying

FIG 1 FIG 2

HEAVY OIL VAPORISER.

THE NEW "ARGYLL" MOTOR CAB.

trial, having been requisitioned by Messrs. Pickfords to convey the *Daily Mail* nightly to Margate and Ramsgate. Following the practice adopted, when one of their 2-ton vans was engaged in delivering the same paper to Brighton, Lewes, and districts, a strict time table was drawn up and adhered to. The distance out and home is 174 miles. The time table was as follows:—

Left *Daily Mail* office	1.30 a.m.
Arrived Ramsgate ..	5.15 ,,
,, Broadstairs ..	6.5 ,,
,, Margate ..	6.20 ,,
,, Westgate-on-Sea	6.35 ,,
Arrived Birchington ..	6.50 a.m.
Returned to London ..	12.30 p.m.,

from which it will be seen that the journey from London to Ramsgate was performed in $3\frac{3}{4}$ hours.

A novel feature of this van is a simplified form of change speed gear mechanism, in which the operating lever moves transversely across the footboard, instead of longitudinally with respect to it. The engine of this car was also fitted with automechanical inlet valves, which the manufacturers are satisfied, materially improved the pulling power of the engine over such an up-and-down road.

Locomotive and Railway Engineering.

By C. EDGAR ALLEN.

The "Raymond-Phillips" System of Automatic Train Control.—One of the most promising of the numerous attempts to devise a reliable and at the same time comparatively inexpensive system for the automatic control of trains is that known as the "Raymond-Phillips" system, a successful demonstration of which was given a few weeks ago on the North Staffordshire Railway at Stoke-on-Trent. This experimental installation has been in operation for the last two years, during which period it has given entire satisfaction. The mechanism involved is very simple in character and consists of an apparatus on the locomotive which is actuated by tripping levers on the permanent way working in conjunction with the ordinary signals whereby the position of the latter are indicated both to the driver and the signalman.

The apparatus on the locomotive is pneumatically operated, and not only is the position of the actual signal semaphore repeated by miniature semaphores in the cab, but should for any reason the driver overlook the danger signal, his attention is attracted to the state of affairs by means of a hooter, and further, the brakes are gradually applied automatically. The action of the pneumatically operated semaphores on the locomotive and the manner in which the hooter is sounded and brakes applied will be readily followed by the aid of Fig. 1.

The vacuum reservoir is normally in connection with the semaphore gauges through the valves *A* and *B*, so that the semaphore arms are kept depressed. When the striking lever *E* is deflected by striking the tripper mechanism fitted in the permanent way, the weighted end of lever 3 drops and locks the striking lever in the deflected position, the piston valve *A* falls cutting off the vacuum at pipe 18 and permits air to enter the gauge pipe 19, the distant semaphore arm is consequently raised to danger, and at the same time the other end of the valve lever 3 raises piston 6 so that air enters the train pipe through the syren fixed near the indicators

To restore the signal the lever of the three-way cock is turned to the right so as to connect the reservoir through pipes 15 and 13 with the bottom of cylinder 8, the piston is pulled down and lever 3 restored so that the striking lever *E* resumes its vertical position; the piston 17 of valve *A* is also restored and the vacuum reservoir is again connected with the semaphore gauge, the arm of which is thereby depressed to the "clear" position.

The "home" valve lever is similarly actuated, but when it falls lever 5 is also depressed. This lever controls the "distant" valve and consequently both semaphore arms go to "danger" as in the case of ordinary line signal work. It will be observed that the "distant" lever 3 operates the "distant" valve only.

The normal position of the three-way cock is with the lever downwards. This lever is heavily weighted to secure its restoration to this position so that the bottoms of the cylinders 8 and 9 are freely exposed to the atmosphere through pipes 13 and 14 to ensure that the pistons 6 and 7 shall rise freely when the controlling levers are actuated. Fig. 1 shows the normal position of the levers with respect to the cylinders. It will be seen that in the event of the connecting links or pins breaking the pistons would drop to the bottom of the cylinders and expose the train pipe to the air. The striking levers *E* and *F* are each mounted on separate bushes to secure free movement, the drawing shows the fitting of the lever *E*, the bush 23, and common axle 24. The spring inserted in the jaws of each striking lever is held in position by the bolts marked 25, and in the event of the striking end of the lever breaking, the arms of the lever would be forced apart, the valve lever would drop, and the breakage would thus be notified.

The mounting and length of the striking lever is arranged to strike the tripper just above the integrally jointed blades of the lever. It will be observed that the reservoir is normally only in connection with the valves *A* and *B*, these are so fitted that there is little likelihood of a leakage into the vacuum. The object in providing a separate reservoir for working the mechanism is to render it independent of the brake reservoir or train pipe so that when the latter is operated either through the

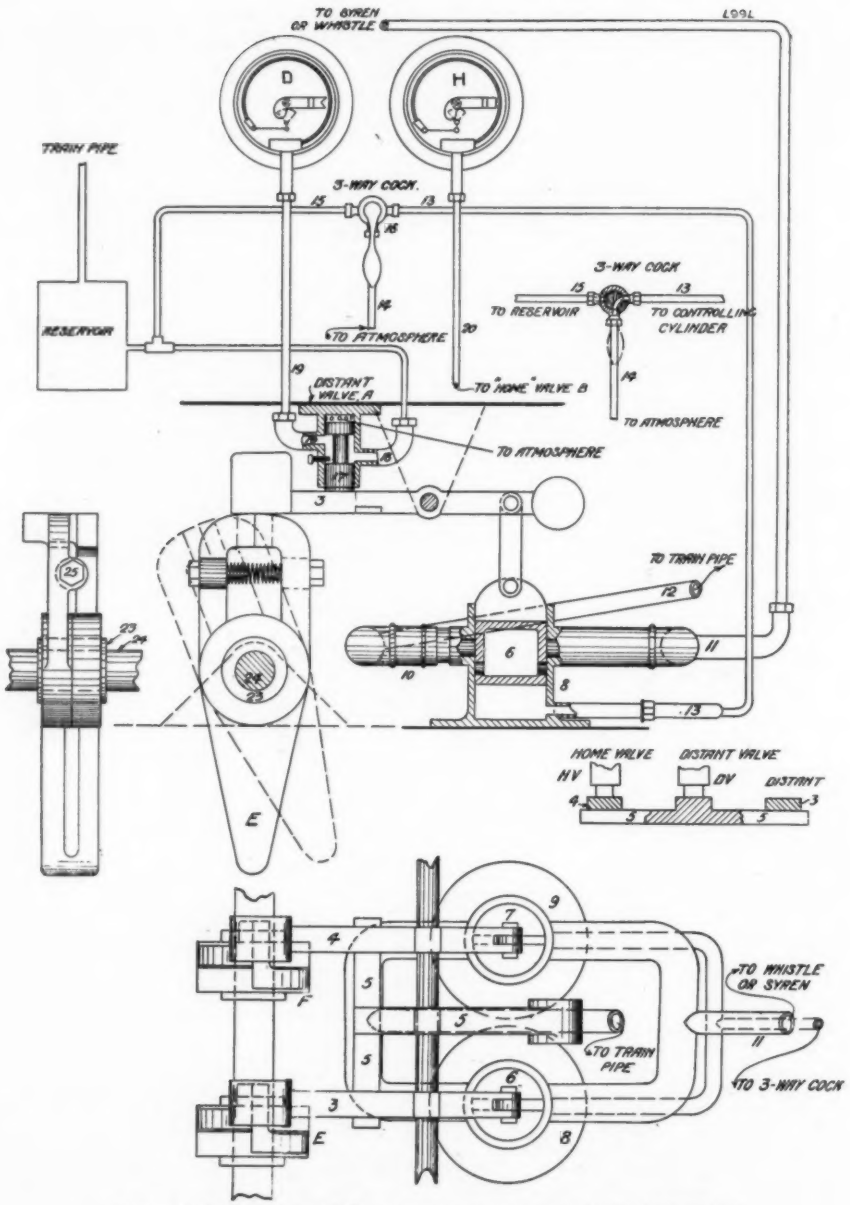


FIG. I.—THE "RAYMOND-PHILLIPS" SYSTEM OF AUTOMATIC TRAIN CONTROL: DETAILS OF ENGINE APPARATUS.

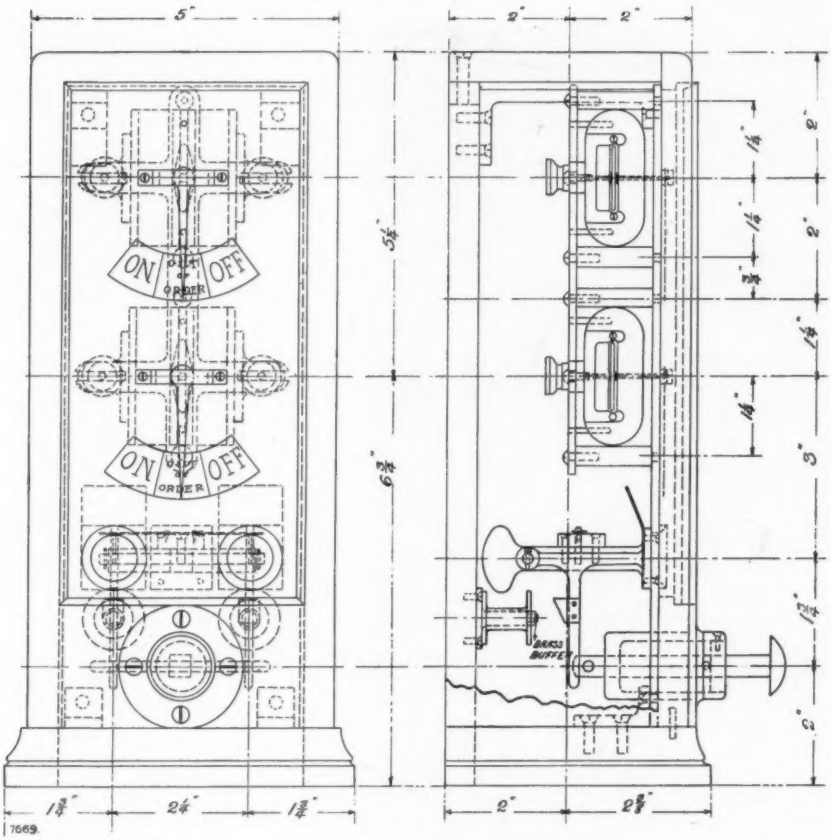


FIG. 2.—DETAILS OF SIGNAL BOX REPEATER APPARATUS.

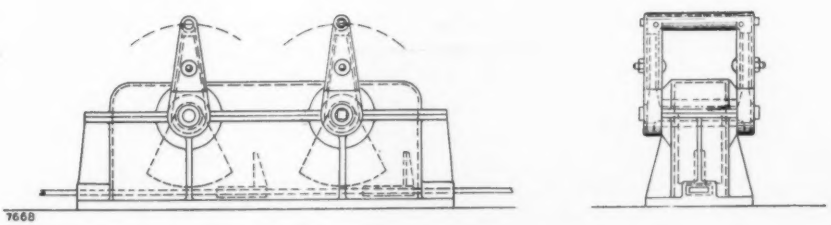


FIG. 3.—DETAILS OF TRIPPERS.

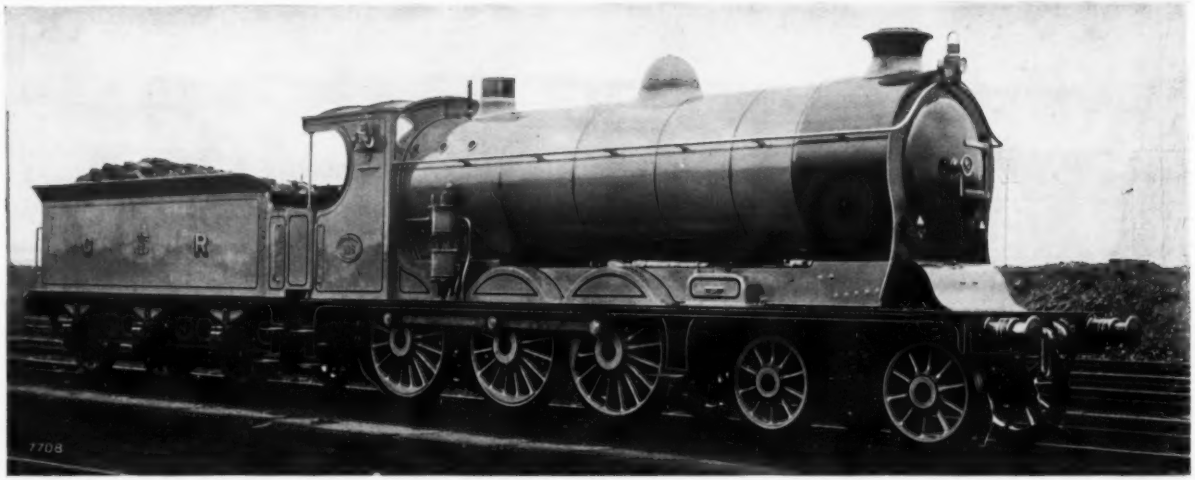


FIG. 4.—SIX-COUPLED BOGIE GOODS ENGINE; 918 CLASS, CALEDONIAN RAILWAY.

communication cord or otherwise the semaphore gauges are unaffected.

That portion of the apparatus installed in the signal box is electrically operated in a simple and inexpensive manner, and is shown in Fig. 3. This repeater simply repeats the condition of the trippers, and shows whether they are "on," "off," or "out of order." It will be observed that the discs drop immediately the circuit is broken, which takes place should the tripper be damaged or should any tampering take place with same, or when the tripper is struck by the lever on the engine in the event of such engine passing the signal at "danger." When the disc drops, a local circuit is also closed which causes a bell to ring in the signal box, and such bell continues ringing until the disc is replaced by means of a plunger fitted in the repeater. It may be added that a double signal vacuum gauge is now used on the engine, that is, the "home" and "distant" signals are fitted together in one gauge instead of using two gauges as shown in Fig. 1, the double type being neater in design.

The system appears to have been well thought out, and the relatively low cost of installation should lead to its extensive application.

Six-Coupled Bogie Goods Engine "918" Class, Caledonian Railway.—This engine has been designed principally for handling the heavy fast goods traffic on the Caledonian Railway, and is the first purely goods engine of the bogie type built by that company.

The cylinders are as large in diameter as it has been possible to make them, viz., 19 ins., with a stroke of 26 ins., and still retain the direct Stephenson link motion with valve chest between the cylinders.

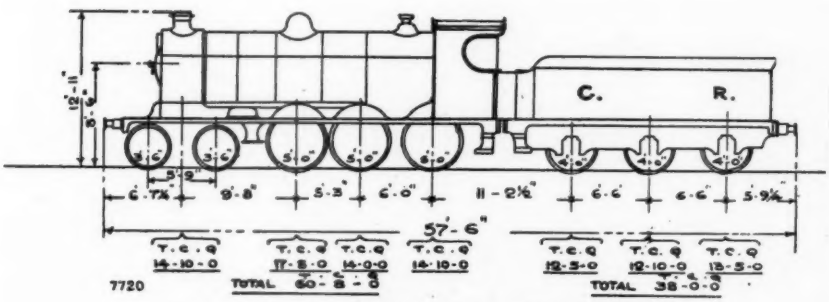


FIG. 5.—SIX-COUPLED BOGIE GOODS ENGINE. CALEDONIAN RAILWAY.

As in the 55 or Oban Class the engine is driven from the leading coupled axle, which has the advantage of reducing the incline of cylinders to a minimum if not to the horizontal position. Its bearings have all been increased in size to take additional weight of boiler.

The boiler is the same as that of the new standard as in the 1903 class, with the exception of being shorter in the barrel and in the firebox. The tubes are of mild steel galvanised, and the firebox crown is stayed directly with screwed stays to the outer shell. Half an inch total side play is provided for the trailing axle, a knuckle joint being placed in the trailing coupling rod to permit of this.

It has steam reversing gear in which is retained the reversing lever and notch-plate.

The stuffing boxes of valve spindle and piston rod have metallic packing.

The safety valves are of the double type, having four valves 4 ins. diameter, with independent springs, which are set for a working pressure of 175 lbs. per sq. in. Sand boxes have been fitted to the driving wheels, and to admit of sanding for backward running when required they have also been fitted to the trailing wheels.

The engine is equipped with the usual Westinghouse brake fittings, and has also an ejector and "through" pipes to enable it to work vacuum brake fitted trains when required. Although designated a goods engine, it is well adapted for running very heavy passenger traffic.

The following are the principal dimensions, &c.:—

Cylinders, diameter	1 ft. 7 in.
,, stroke	2 ft. 2 in.
Wheels, diameter on tread, bogie ...	3 ft. 6 in.
,, ,, ,, coupled...	5 ft.
Boiler, height of centre from rails ...	8 ft. 6 in.
,, length of barrel	14 ft. 0⅛ in.
,, diameter of barrel	5 ft. 3½ in.
Boiler, thickness of barrel plates ...	11/16 in.
Firebox shell, length outside ...	6 ft. 5 in.
,, breadth outside at bottom	4 ft.
,, depth from centre at front	5 ft.
,, depth from centre at back	4 ft. 3 in.
,, thickness of plates, sides...	5/8 in.
,, thickness of plates, crown	¾ in.
Tubes (steel) 242, external diameter	2 in.
,, ,, distance between tube plates ...	13 ft. 6½ in.
,, ,, height of chimney above rail ...	12 ft. 11 in.
Heating surface, firebox	128 sq. ft.
,, ,, tubes	1,890 sq. ft.
Total	2,018 sq. ft.
,, ,, grate area	21 sq. ft.
Working pressure	175 lbs. per sq. in.
Weight of engine in working order	60 tons 8 cwts.

TENDER.

Capacity of tanks	3,570 gallons.
Fuel space	4½ tons.
Diameter of Wheels	4 ft.
Weight of tender full	38 tons.
Weight of engine and tender in working order	98 tons 8 cwts.
Engine and tender, length over buffers	57 ft. 6 in.

The engine was built at the company's St. Rollox workshops to the designs and under the supervision of Mr. J. F. McIntosh, Locomotive Superintendent.

New Motor-car Vans.—To accommodate the general traffic in motor-cars, and particularly in connection with the production of the many car factories springing up throughout their system, the Caledonian Railway have built a number of commodious six-wheeled vans for the exclusive transit of these vehicles.

The following are the particulars, dimensions, &c.:—

The outside dimensions are 30 ft. over body, breadth 8 ft. ¾ in., height at centre 8 ft. 10 in., and at side cornice 7 ft. Height from rail at centre 12 ft. 9⅞ in., and at side

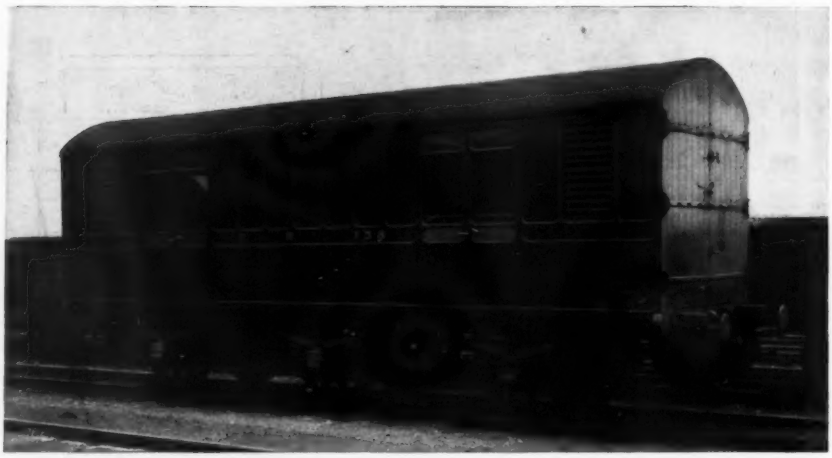


FIG. 6.—NEW MOTOR CAR VAN. CALEDONIAN RAILWAY.

cornice 11 ft. The underframe is 30 ft. long, giving 33 ft. 8 in. over the buffers.

The sole-bars and cross-members of the underframe are of steel channels, the longitudinals and diagonals being of oak, secured by angle bars and plate knees. The wheels are 3 ft. 9 in. diameter on tread, and 9 ft. between centres, giving a total wheel base of 18 ft.

The body framing is of teak, panelled in mahogany. There are two double folding doors on either side, each giving a clear opening of 4 ft. 2½ in., with large sliding windows, which give the interior a good light. The waist panels on doors are of slate for writing purposes. Each side door is fitted with a slip bolt and carriage standard lock. The centre panel at either end on both sides is louvered, and lined inside with perforated zinc. The roof is of galvanised steel plate ⅛ in. thick, supported by light steel roof bars of channel and T sections.

The two folding end doors are vee-boarded, and hung from the corner pillars by wrought-iron hinge straps, three to each door, the centre hinge straps having a stud and cotter fastening. There is also a slip bolt fastening inside. The doors give openings the full width and height of the van. There are four wheel bars stretching across the vehicle, sliding on angle bar brackets, having holes 2 in. pitch for adjusting purposes, giving accommodation for two ordinary sized motor-cars. There are also notched bars along the sides, having a shackle and strap attachment for more securely fixing the load.

Two steel plates 10 in. × ¼ in. thick run the full length of the floor inside, on which the wheels of vehicles rest.

The vans are fitted with dual brake, and have "through" pipe connections for steam heating, as well as "either side" hand brake.

The tare is 12 tons 19 cwt.; load, 6 tons.

They have been built at the company's St. Rollox workshops to the designs and under the supervision of Mr. J. F. McIntosh, Locomotive Superintendent.

4-4-4 Type High Speed Locomotive, Bavarian State Railways.—This locomotive, which is illustrated in Fig. 7, has recently been on view at the Nuremberg exhibition, and represents the latest type of high-speed locomotive turned out of the works of J. A. Maffei, Munich, to whom the writer is indebted for the photograph and information supplied. The fineness of its parts and proportions together with the means adopted to reduce head resistance, at once suggest that the engine has been designed for high-speed work for which the engines turned out from the Maffei shops are justly famous, and it is expected that the new type will maintain a normal speed of ninety-four miles per hour with a light load.

The engine, which is of bar frame construction, has four cylinders arranged in the same transverse line, with the high-pressure cylinders outside and the low pressure inside all driving the leading pair of coupled wheels. The valves are of the piston type of ample

dimensions, the low-pressure valves being fitted at each end with two small supplementary valves connected up to the expansion gear, and by which live steam is admitted to the low-pressure cylinders whenever the cut off exceeds 70 per cent. as in starting or up heavy gradients. One set of valve gear serves for the four valves, and the intercepting valve has been eliminated.

The following are the principal dimensions of the engine :—

Cylinders.

High pressure (2), diameter	16½ in.	Stroke	25 $^{9}/_{16}$ in.
Low pressure (2), diameter	24 in.		

Wheels.

Driving diameter	7 ft. 2⅝ in.	Bearing, diameter	3 ft. 3½ in.

Boiler.

Steam pressure	205·81 lbs.	Diameter internal	5 ft. 6$^{7}/_{8}$ in.

Tubes.

Ordinary number	208	Heating surfaces, tubes ordinary, inside	2130·5 sq. ft.
,, inside diameter	2 in.		
Superheat pipe carriers, number	18	Heating surfaces, superheat pipe carriers inside	409 sq. ft.
Superheat pipe carriers, inside diameter	5 in.	Fire-box, heating surface, inside	177·5 sq. ft.
Length between tube plates	16 ft. 1 in.	Total heating surface	2717 sq. ft.
		Grate area	50·5 sq. ft.

Weights.

Under driving tires (maximum load)	32 tons (metric)	Total of engine with maximum load	84 tons (metric)
Under bogie truck	27·5 tons (metric)	Total wheel base of engine	38 ft. 4½ in.
,, fire-box truck	24·5 tons (metric)	Length of engine	45 ft. 2 in.
		Wheel base of tender comprised	60 ft. 7½ in.

Capacity of Tender.

Coal	8 tons metric	Total length of engine and tender	69 ft. 4 in.
Water	26 tons metric (cubic metres)=5,730 gallons		

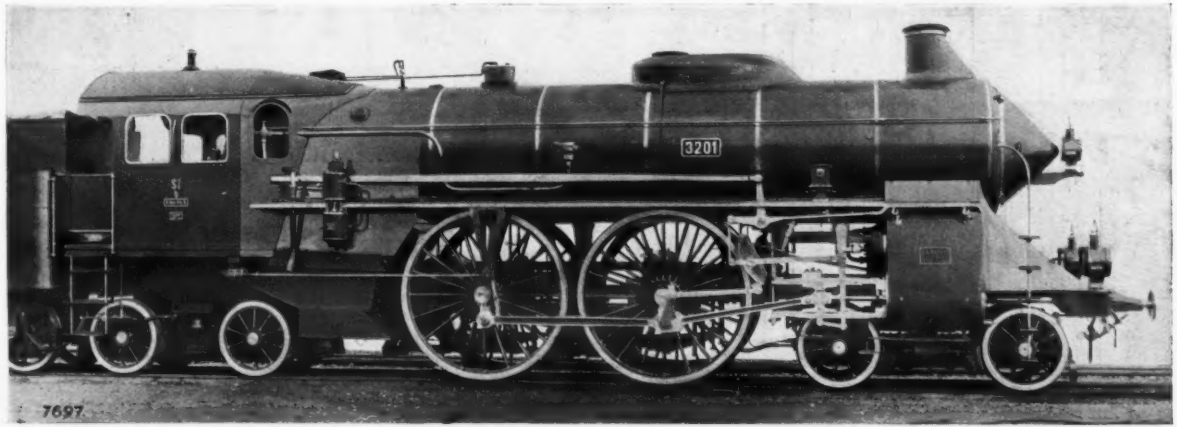


FIG. 7.—4-4-4 TYPE HIGH SPEED LOCOMOTIVE. BAVARIAN STATE RAILWAYS.

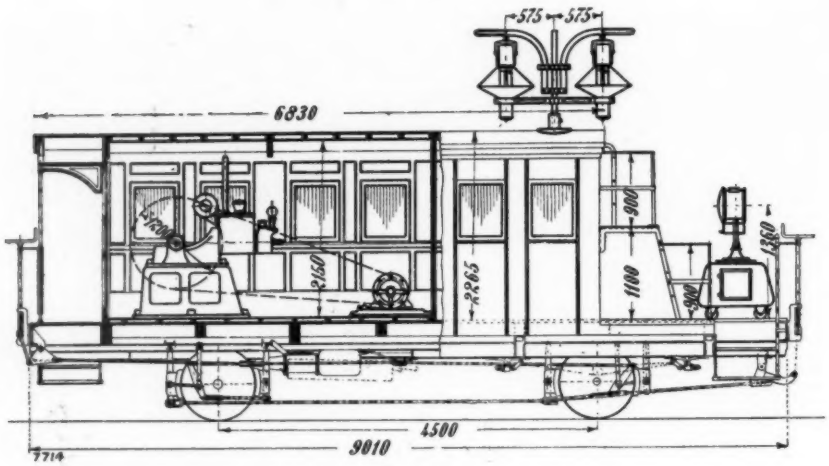
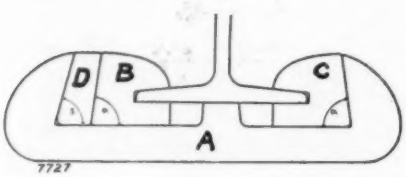


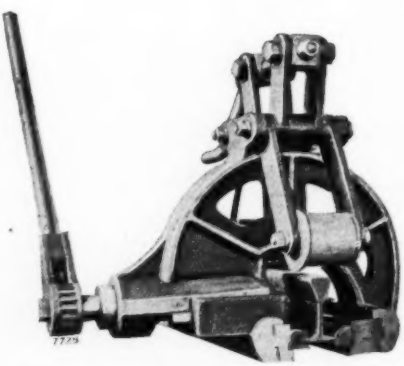
FIG. 8.—INSPECTION CAR FOR THE SIMPLON TUNNEL.

Inspection Car for the Simplon Tunnel.—The car constructed for inspecting the walls and arch of the Simplon tunnel is fitted with a 6 h.-p. benzol motor, driving a 50-ampere, 65-volt continuous, shunt-wound dynamo, to provide means of illumination independently of the tunnel circuit. The fuel tank holds sufficient for a ten-hours' supply, and a reserve stock of equal amount is provided. To prevent contaminating the air with fumes, the products of combustion are condensed, water from a 150-gallon tank being pumped into the evaporating chamber above the cylinder. The switchboard supplies current to seven different circuits, one for the head light, five for arc lamps on the roof, and one for the incandescent lamps inside the car. A pair of 10-ampere differential arc lamps are mounted on the roof, the light being first reflected from white enamel screens to give uniform illumination and avoid heavy shadows.

The car is also intended for use outside the tunnel, for which purpose the two lamps on the top are dismounted, and replaced by five 23-ft. masts each supporting an arc lamp to which current is supplied through double insulated cables which, when not in use, are wound on rollers in the car. By means of these lamps a section of over 250 yards of track can be illuminated for inspection.

The head light is mounted on a frame running on rails on the car floor, and can be swung in any direction around its vertical axis and about 50 degs. above and below the horizontal. It is fitted with a plain glass for outside work and a ground glass for use in the tunnel.





FIGS. 9 AND 10.—THE "SCHEINIC AND HOFMAN" RAILWAY CHAIR.

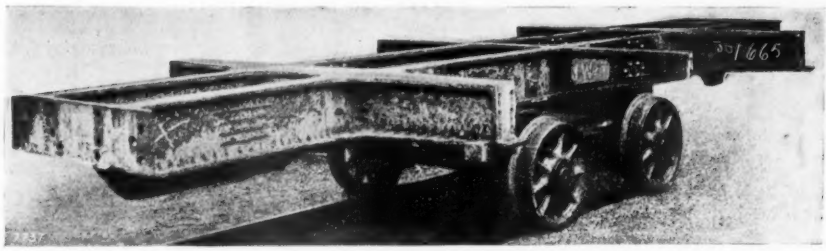


FIG. 11.—CAST STEEL TENDER FRAME: THREE MAIN CASTINGS FITTED.

The "Scheinic and Hofman" Railway Chair.*—This chair is designed to support the rail joints and prevent jolting. As shown in Fig. 9, it consists of a base *A*, and two clamping pieces, *B.C.*, the latter of Martin steel, rolled, cut into lengths and provided with milled grooves to take the rail foot, the whole being tightened by means of a wedge, *D*, the angles α and β being selected with a view to ensure a firm connection between the rail foot and several parts of the chair. The clamping pieces are covered with thin sheet zinc and forced on by the aid of a parallel vice, Fig. 10, in the cold, this method being the best where the rails are for electric traction, as preventing oxidation. The base on the other hand is made red hot and inserted under the rail by means of a shovel, whereupon the wedge is driven home, care being taken to strike the latter in a direction parallel with the rail. If the wedge be too small, a liner of steel plate can be inserted. Where the rail joint is supported by a sleeper, the chair may be modified so that the bent fishplates are held by the clamping pieces.

Cast Steel Tender Frames.—A novel departure is being introduced on the Central Railroad of New Jersey in the shape of tender frames made up chiefly of cast steel, and which, says *The American Engineer and Railroad Journal*, have the advantage of being lighter than a built-up steel frame of equal strength. The new frame is made principally of cast steel, and comprises, exclusive of the bumpers, floor and attachments, but thirteen separate parts of which eleven are cast steel. The three largest of these castings form the main part of the frame, including the centre sills, bolsters, draft casting and the cross support in the centre. The other eight cast steel parts comprise the diagonal braces, the location of which is clearly shown in the illustration. The joints between the three principal castings are made just inside the bolsters, at points most convenient for casting and the clearance of attachments.

The "I" section has been used throughout, and much care was given to eliminate any large masses of metal at any single point, and except at the joints between the castings and diagonally across the junctions there is no section thicker than 1 in.

The centre sills are 12 in. deep with a 1 in. web and a 5 in. flange, and the side sills are 10 in. channels securely rivetted to the castings at the bolsters, corners, &c. The draft attachments at either end are cast integral with the sills and made amply strong by the proper location of numerous webs and flanges. The lugs and projections noticed on the centre castings are for attaching a water scoop and the auxiliary reservoir.

* F. Steiner. *Elektrische Bahnen und Betriebe.*

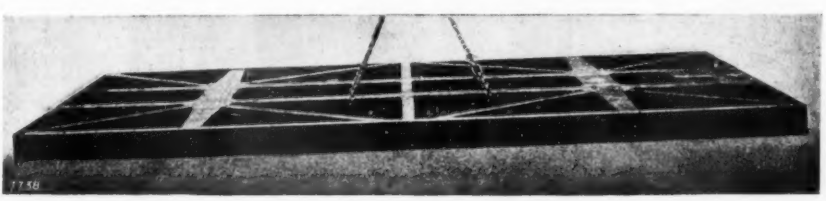


FIG. 12.—CAST STEEL TENDER FRAME COMPLETE.

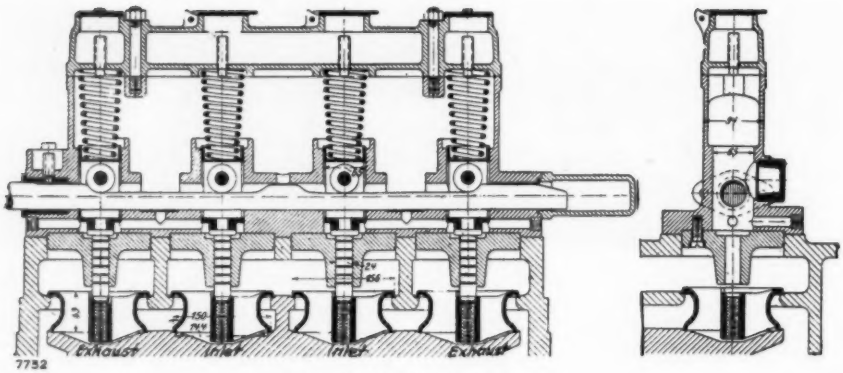


FIG 1.—DETAILS OF POPPET VALVES.

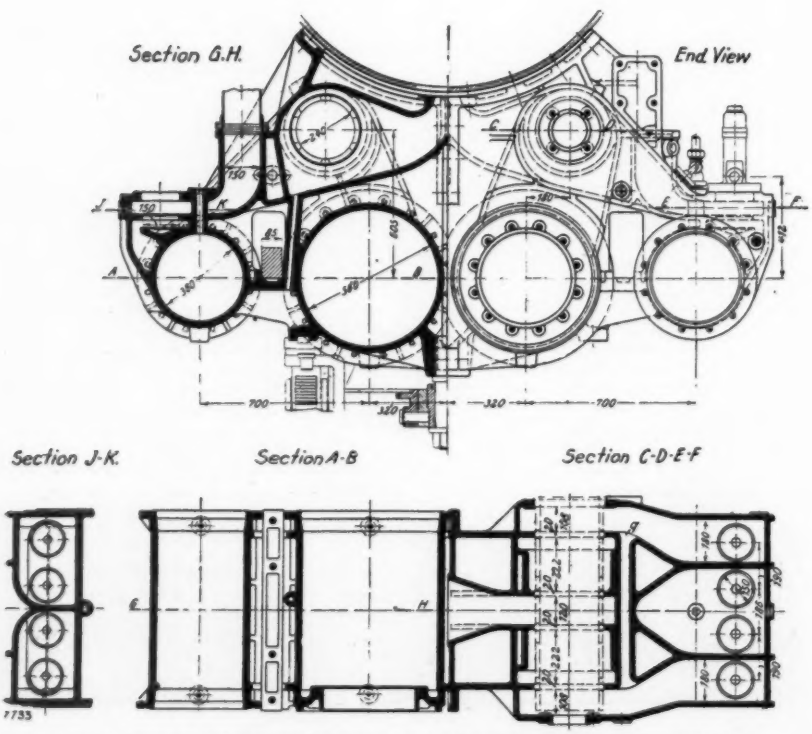


FIG. 2.—CYLINDER ARRANGEMENT OF POPPET VALVE LOCOMOTIVE, PRUSSIAN STATE RAILWAYS.

Poppet-Valves on Locomotives.—The rapidly increasing application of superheating in locomotive practice on the Continent has led to some interesting developments in connection with valve design, some details of which have been furnished by those responsible for the equipment—viz., the Hannoversche Maschinenbau-Actien Gesellschaft, Hanover-Linden, Germany, to our contemporary *The Railway and Engineering Review*. With the idea of securing such advantages as the steam-tight closing of the valves, rapid admission and cut-off, and the elimination of stuffing boxes, a small tank locomotive sent to the works for repairs was made the subject of the first experiment. This was of a 2 ft. 6⅝ in. gauge, 0-4-2 type, with simple cylinders, 9⅞ by 17¾ in., and 36 in. driving wheels. Its boiler carried 156 lbs. of steam pressure, and contained 461·5 sq. ft. of water-heating surface after a "Pielock" superheater of 75·3 sq. ft. had been built in.

The cylinders only were renewed, and in consideration of the use of superheated steam the desired increase in the diameter of the cylinders from 9⅞ in. to 10¼ in. was easily attained. The tractive force was now 4,850 lbs., or 1-5·8 of the adhesive weight. The distributing gear remained as it was—viz., "Allan's" link gear—with the exception, however, of the slide-valve connecting rod, which was replaced by a rod provided with lifting projections in the form of curves (Fig. 13).

The four valves (two inlet valves towards the middle and two outlet valves towards the ends) are placed in a row one behind the other. They are constructed as double seat-valves. Their spindles are fitted with so-called labyrinth (condensation rings) packing only, which, as experience in steam-engines goes to show, can, without difficulty, be made to work perfectly steam-tight, and at the same time almost frictionless, when accurately constructed. The valves weigh 7·3 lbs., and are weighted by springs; they run on rollers on the rod with lifting projections mentioned above, which has four lifting curves arranged symmetrically one to the other. The valves are raised by the regular to and fro motion of the rod and closed again by the pressure of the springs. The valves are guided by rollers on the rod fitted with lifting curves. This obviates the danger of the valves striking their seats, as by this means they merely touch the latter quite gently.

Exhaustive trials to test the steam consumption of this locomotive were made with an exactly similar engine fitted with slide-valves, working with saturated steam, and performing exactly the same train service. The results of these trials with the poppet-valve locomotive working with 520-524° F. showed a saving in water to the extent of 30·6 per cent., and a saving in coal of 19·5 per cent. over the slide-valve locomotive with no superheat. After both locomotives had run about 11,000 miles, these trials were repeated. No repairs of any kind had been made on the poppet-valve locomotive, but the locomotive working with saturated steam had been fitted with sixty-six new tubes. The results showed the poppet-valve locomotive to achieve a saving in water of 25·2 per cent., in coal of 17·5 per cent.—a highly satisfactory result when the slight superheating of 520-540° F. is taken into consideration.

The next application of the poppet valve was to a 4-4-2 balanced compound passenger locomotive built for the Prussian State Railways, who possess one hundred and forty of this type, some of which are fitted with "Pielock" superheaters. In the present example the superheater was not put in because of the railway authorities expressing some doubt as to its advantage where compounding was resorted to.

Contrary to the usual mode of construction adopted for this type, the high-pressure cylinders were placed outside and the low-pressure between the frames, as a better balancing of the engine could thereby be obtained. The cylinders are cast with half saddles so that a high- and low-pressure cylinder with the valve-chest is contained

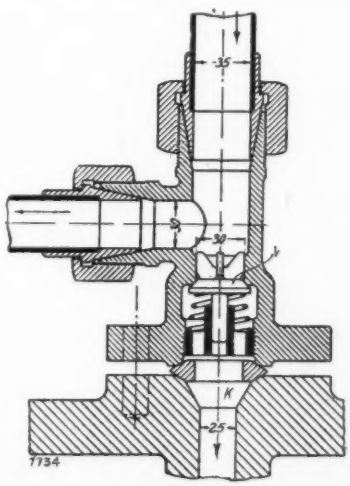


FIG. 15.—STARTING VALVE.

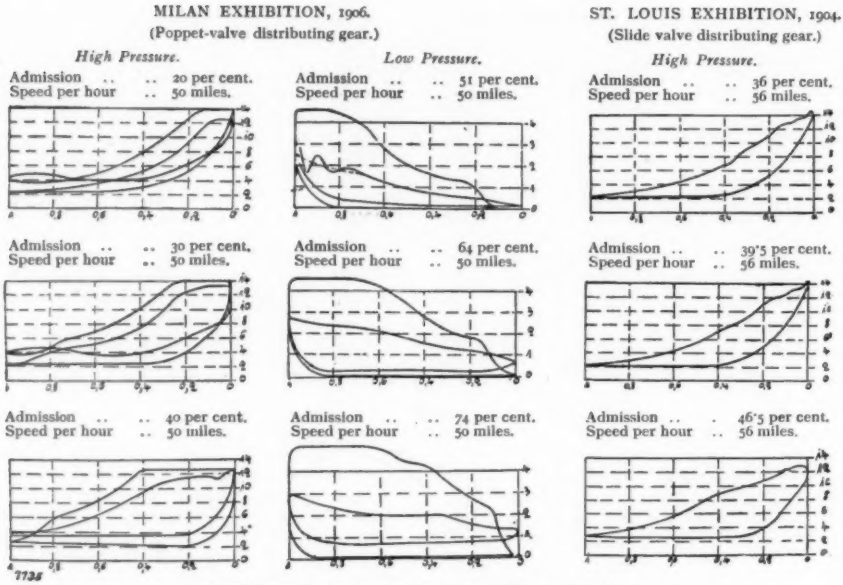

MILAN EXHIBITION, 1906.
(Poppet-valve distributing gear.)
High Pressure.
Low Pressure.
ST. LOUIS EXHIBITION, 1904.
(Slide valve distributing gear.)
High Pressure.
Admission .. .. 20 per cent.
Speed per hour .. 50 miles.
Admission .. .. 51 per cent.
Speed per hour .. 50 miles.
Admission .. .. 36 per cent.
Speed per hour .. 36 miles.
Admission .. .. 30 per cent.
Speed per hour .. 50 miles.
Admission .. .. 64 per cent.
Speed per hour .. 50 miles.
Admission .. .. 39·5 per cent.
Speed per hour .. 56 miles.
Admission .. .. 40 per cent.
Speed per hour .. 50 miles.
Admission .. .. 74 per cent.
Speed per hour .. 50 miles.
Admission .. . 46·5 per cent.
Speed per hour .. 56 miles.
7736

FIG. 16.—COMPARISON OF SLIDE AND POPPET INDICATOR CARDS.

in a single casting. The four cylinders are thus set across the locomotive on the centre line of the leading truck (Fig. 14).

The connecting rods for all cylinders are coupled to the forward axle, the cranks of the high- and low-pressure cylinders on one side being set at 180 degrees to each other, while the cranks of the two high-pressure and of the two low-pressure cylinders are set at an angle of 90 degrees to each other.

The valve-gear is of the "Heusinger" type, "von Borries'" patent, in which each pair of slide-valves on one side of the engine is driven by a single eccentric between the frames, and the motion of the valves for the outside cylinders is taken from that of the neighbouring inner cylinder. The valve-motion has in principle remained unaltered from the existing construction of this class of locomotive, with the difference that in place of the valve-rod of a high-pressure cylinder, a rod with curved projections for actuating the valves is attached. Some of the dimensions of the distributing valve-motion have, of course, been modified, because, as has been explained above, the low-pressure cylinders have been placed inside the frames. The position of the valve-motions of the high- and low-pressure cylinders towards each other has been so arranged by suitable dimensions of the transmission lever that a steam-admission of 40 per cent. in the high-pressure cylinder corresponds to an admission of 74 per cent. in the low-pressure cylinder. The greatest admission in the high-pressure cylinder is 68 per cent.; that in the low-pressure cylinder 89 to 90 per cent.

The starting mechanism is of the "von Borries'" type, in which the throttle consists of two flat-valves, one on top of the other. As soon as the small regulating slide-valve is opened, steam enters by an aperture through a special tube into the receiver. A connecting tube fitted with a return-valve is, however, attached to this steam inlet pipe, and enters the high-pressure cylinder at the centre of the latter (Figs. 13 and 15). The high-pressure cylinder is consequently still supplied with steam behind the piston even when the poppet-valves have already been cut off. By this means the counter-pressure of the steam emanating from the receiver and getting in front of the piston is done away with. The locomotive, therefore, always starts with the low-pressure cylinders without the high-pressure pistons being able to exercise a counter-pressure.

The four valves, two for the inlet towards

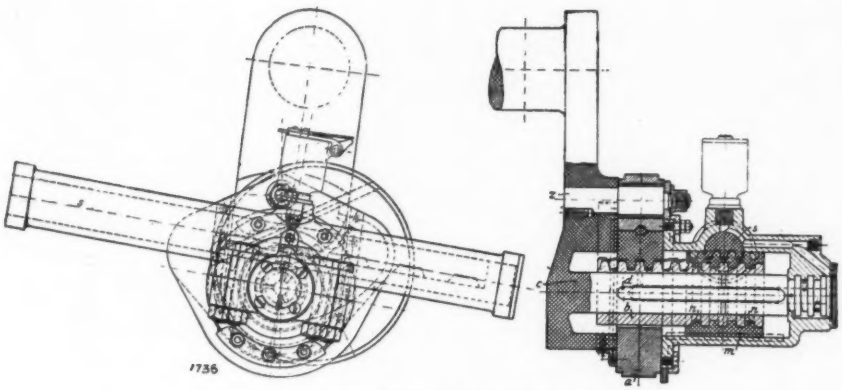


FIG. 17.—DETAILS OF LENTZ VALVE GEAR.

the centre and two for the outlet towards the ends, line in a plane, and are worked by means of the rod with lifting projections already mentioned.

An exact calculation of the degrees of acceleration pressure arising shows that comparatively weak springs suffice to promptly close the valves, which weigh less than 10 lbs., even at 300-350 revolutions.

One of the most important advantages of this valve-motion is that it reduces the speed of the steam while passing through the admission. Diagrams showing the velocity of the steam taken with a cut-off at about 40 per cent. show that the rate of admission is about 40 per cent. less than with ordinary valve gear, which naturally gives more complete steam diagrams in ratio to the wire drawing during admission.

Fig. 16 shows a series of indicator cards which were taken when the locomotive with poppet-valve motion was running at a speed of fifty miles per hour, and, for the sake of comparison, a series of cards taken at the testing plant of the St. Louis Exposition on the same locomotive fitted with slide-valves.

In another locomotive, constructed for the Russian State Railways and exhibited at the Milan Exhibition, the poppet-valves are placed horizontally, the inlet valves being on the inside and the exhaust valves outside. They are operated by cams, placed on a shaft which received its movement from the novel reversing gear shown in Fig. 17.

In this gear the eccentric, *a* (see Fig. 17), rests on the journal *z*, fixed in the counter crank, movable on a box *b*, which slides along journal *c* placed in the centre of the axle, but is forced by wedge *d* to revolve with the axle. The box *b* is provided with oblique teeth, which engage with corresponding teeth on the eccentric *a*. The longitudinal sliding of box *b*, therefore, causes the eccentric to oscillate on journal *z*, and thus produces a displacement of the centre of the eccentric. A non-rotary coupling box, *m*, with four annular shoulders, *nn*, on the inside is fixed on box *b*. These shoulders allow box *b* to freely revolve. This coupling box has oblique teeth on the outside, which engage with similar teeth on rod *s* leading from the driver's stand. As soon as this rod is displaced in a direction parallel to the longitudinal sense of the locomotive, the axes of both coupling box *m* and box *b* are simultaneously displaced, and thus turn the eccentric sufficiently to bring about the change in the admission and reversing movement.

Electrical Notes.

By ANDREW STEWART, A.M.I.E.E.

Railway Electrification. — The decision of the Midland Railway Co. to electrify the Lancaster-Morcambe-Heysham section of their line, and the proposal of the London and North Western Railway Co. to construct an electric line from Euston to Watford, has stimulated interest in railway electrification problems. The question becomes more complicated in view of Lord Claud Hamilton's remarks at the meeting of the East London Railway Co., some time ago, to the effect that the electrification of the Metropolitan Railway had not proved very satisfactory from a financial point of view. Of course if Lord Claud Hamilton had not been selecting a particular case to justify the disinclination of his co-directors to electrify any portion of their system, he might have instanced the success, engineering and financial, which has attended the electrification of sections of the North Eastern and Lancashire and Yorkshire railways. No doubt the particular lines, cited as not having justified the hopes of those who looked forward to electrification as a cure for all the ills that can afflict a railway, have not become remarkably prosperous as a result of electrification, but they have not been electrified sufficiently long to make the full results of the change apparent; moreover, they are so heavily burdened by capital charges incurred for purposes other than electrification that it would be difficult to make them pay under any circumstances, while any saving in power costs is to some extent balanced by an increased traffic expense due to a more frequent service and larger train staff. The only hope of financial salvation for such lines is by making them sufficiently popular to attract traffic which has hitherto travelled by other routes.

The difficulty of doing this is apparent, and it is rendered still more so in the case of the District, and to a less extent the Metropolitan, by the fact that on the sections where traffic is most likely to be heavy, the railway is paralleled by a motor 'bus service, and with a fine summer such as we have just experienced, an appreciable percentage of the possible travellers prefer to travel on the surface. The failure of the Metropolitan and District Cos. to come up to expectations is due far more to these causes than to any shortcomings either in the method of propulsion or organisation.

The Midland Railway experiment, if an electrically operated standard gauge line can still be called an experiment, will be operated by a single-phase system, the necessary generating plant being installed in the existing power house at Heysham. The pressure of the current at the generating station and on the feeders will be 3,300 volts., transformed down by static transformers along the line to 300, which will be the trolley wire pressure. The periodicity of the system will be 25 cycles per second, thus making the apparatus more or less standard, and avoiding the heavy capital cost of larger transformers which would be necessary were the low periodicities used on several Continental lines adopted.

Between Morcambe and Heysham it is proposed to run three trains per hour, and from Morcambe to Lancaster four trains per hour.

Each train will consist of a motor car with seating accommodation for eighty passengers, and two trailers with accommodation for sixty-four passengers each. The motor car will be equipped with two single-phase motors, each of 150 h.-p., controlled on the multiple unit system. With regard to the overhead system, this is indefinite yet, and we understand that the company, with a view to getting the best, are prepared to receive suggestions with regard to this and the collecting gear, which of course must be standardised from the beginning. In view of this, and the possible extension of the single-phase system to other parts of the line, and perhaps also to other railways, it is somewhat unfortunate that the low line pressure of 300 volts. has been chosen. It is too low to operate heavy trains economically, and involves the company in the expense of an unnecessarily heavy overhead structure to carry conductors of large section, unless of course the feeder pressure of 3,300 volts. is employed on the line and the transformation effected on the train itself. In any case, as we have already suggested, the question of a suitable standard trolley wire pressure and periodicity for

single-phase working is one of the questions which must be settled at an early date, if single-phase working is to develop along rational lines. If each railway company develops along lines which may be considered expedient under a particular set of conditions, we shall reach a chaotic condition worse even than that resulting from dissimilar gauges, for with the extension of electrical working will come a tremendous increase in the use of single and two car trains for developing local traffic, not only around cities, but in very sparsely populated districts, and the electric supply must be more or less uniform to facilitate working at junctions and the interchange of rolling stock, which will, of course, frequently be self-propelled, and must be capable of running over sections of one or another company's line.

The announcement that the London and North Western Railway Co. will, next year, promote a bill in Parliament to enable them to construct an electric line from Euston to Watford, partly under and partly alongside their existing line, was somewhat of a surprise, for though the suburban traffic of the London and North Western Railway has been expanding in common with that of all the large companies running out of London, it was thought that the recent widening of the line for some distance out of Euston had somewhat relieved the congestion that existed. In all probability the single-phase system will be adopted in this case also.

Apropos the decision of the Midland Railway to electrify a section of their line between Morcambe and Heysham, using single-phase system, the accompanying illustration of a single-phase electric locomotive arranged to work on both single-phase and direct-current circuits will prove interesting. The normal horse-power of the locomotive is 600, there being four single-phase commutator type motors each of 150 h.-p. As our readers are aware these may be used on a direct-current circuit as well as on the single-phase circuit for which they were designed; in point of fact, the locomotive illustrated runs on a trolley line having an alternating current voltage of

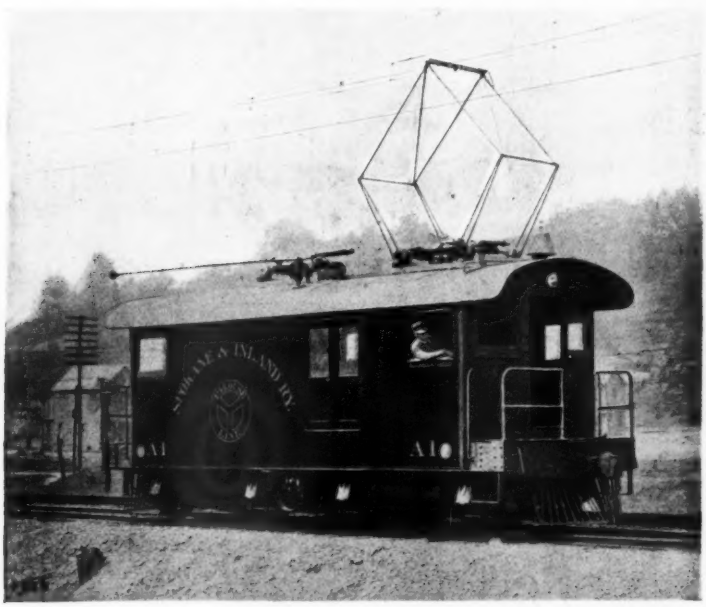


FIG. 1.—ELECTRIC LOCOMOTIVE ARRANGED TO WORK ON BOTH SINGLE-PHASE AND DIRECT-CURRENT CIRCUITS.

6,600 volts on one part of the line, 700 volts on another, and 600 volts direct-current on another. The two alternating current voltages are possible as the locomotive is fitted with transformers reducing the 6,600 volt circuit to 700 volts at which pressure it goes to the motors, and when on the 700 volt section the transformers are merely cut out. The frequency of the supply current is 25 cycles. The pantograph trolley is used to collect the alternating current, and the high-pressure of 6,600 volts is employed only on sections of the line which run through sparsely populated districts. In small towns the trolley pressure is reduced to 700 volts, while part of the line is over tracks served by the Spokane Traction Co. (Washington, U.S.A.), who operate the trolley car service. When operating on this section the wheel trolley with which English engineers are familiar is employed. It can be seen fastened down to the roof of the car in the figure, the pantograph collector being closed when the wheel trolley is in use. The locomotive in question was built by the Westinghouse Co.

The Electrical Equipment of Hasard Collieries, Belgium.—These collieries have a very complete electric power plant, and electrical energy is transmitted to one pit about a mile from the main generating station at a pressure of 2,000 volts. The generating station has four three-phase alternating current generators each of 250 kilovolt-amperes (nearly 300 h.-p. at normal power factor), the periodicity of the system being 48 cycles per second. The generators are excited from direct-current exciters driven by induction motors, though to obviate difficulty when all the plant has been shut down a steam driven exciter having sufficient capacity for one generator is fitted. The usual custom in England is to provide each generator with its own exciter, directly connected thereto, a method which is not only more economical, but less likely to give rise to trouble should the steam driven exciter break down.

The lighting and power requirements in the immediate neighbourhood of the power station are supplied directly at 225 volts, but for all other purposes the energy, which is generated at this low pressure, is transformed up to 2,000 volts and transmitted through armoured cables to the points where it is required. Pumping, haulage, &c., are carried out by electric power on orthodox lines, but interest centres in the electric winding plant, which differs from that used in most collieries, inasmuch as no motor generator or equaliser set is used, but merely a direct current motor with a heavy fly-wheel mounted thereon. This motor is in series with the winding motor, and the energy stored in its flywheel is given out in the winding operation.

As all regulation is by variation of the field excitation, direct current is essential, so that at the Hasard Collieries, the polyphase current is changed to direct by means of a 160 h.-p. motor generator, the direct current voltage being 157. In series with the line which supplies the winding motor is a fly-wheel set consisting of a motor with a cast steel fly-wheel weighing about three tons, and having a radius of gyration of 2·77 ft. This set is capable of absorbing the whole output of the generator at 300 to 600 revs. per minute, and with suitable excitation can develop an E. M. F. equal and opposite to the main E. M. F.

The speed of the winding motor is controlled by varying the E. M. F. impressed upon it, which is done by varying the E. M. F. of the fly-wheel set. This set has the excitation controlled so that for no impressed volts at the winding motor the field excitation of the flywheel set is brought up till its voltage is equal and opposite to that of the generator. By varying this and reversing the direction, an E. M. F. variable between zero and twice the generator E. M. F. may be applied to the winding motor.

When full speed is required for the wind the fly-wheel set has its motor E. M. F. assisting the generator E. M. F., thus acting as a booster, the power which drives it being the stored up energy in the fly-wheel.

This system has one advantage over those already described in our columns, in that the breakdown of the fly-wheel set does not paralyse the system, for winding can still be done without the fly-wheel set, though at reduced speed.

A feature of the winding engine at this colliery is that the rope drum consists merely of a deep groove, the sides being of light sheet iron. The rope winds on the top of the preceding turn instead of side by side as usual. The effective diameter of the winding drum varies from 9 ft. to 15 ft. The cage carries two tons, and the acceleration is 2·46 ft. per second, per second, the normal winding speed being 82 ft. per minute. Experiments show an efficiency $\frac{\text{useful work at rope}}{\text{output at generator}}$ varying from ·58 to ·61.

An Electric Canal Tow Boat with Overhead Trolley.—A vessel which has proved useful on some of the German canals is illustrated in Fig. 2. It consists

of a triple-screw tug, which, though normally operated from an overhead trolley system strung along the bank, has a sufficiently large battery of accumulators to enable it to maintain good speed over a pretty long stretch of river or canal without the aid of the external supply.

The vessel has three screws, the centre propeller driven by a 25 h.-p. and the outer propellers by 20 h.-p. motors. By suitable grouping, the propellers can be run at speeds varying from 200 revs. to 500 revs. In order to enable the boat to operate independently of the supply on the banks of the canal a battery of accumulators is arranged as shown at *A*. These have a capacity of

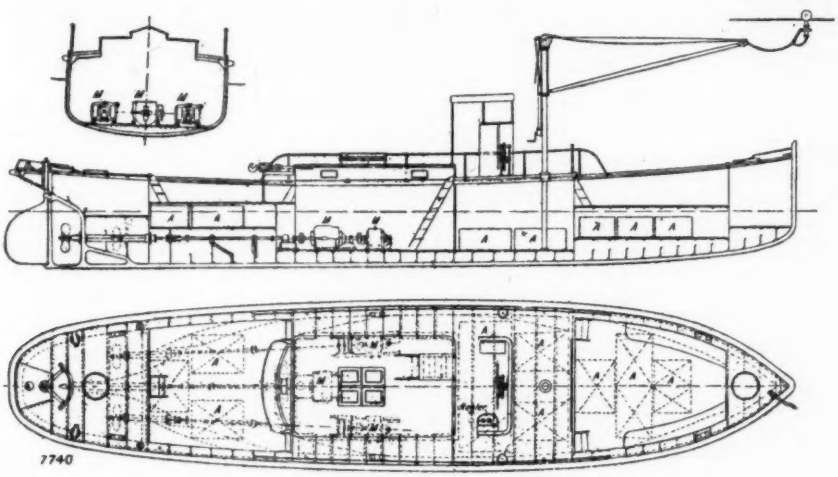


FIG. 2.—ELECTRIC CANAL TOW BOAT.

224 ampere hours, and their use, *inter alia*, improves the trim of the boat. The vessel can be manipulated and steered by one man, as the motors are controlled by small controllers no larger than the engine room telegraph on a steam vessel.

Petrol Electric Cars on the North-Eastern Railway.—We have from time to time* noted the developments which have taken place in petrol electric autocars on rails and on common roads; the latest autocar of the North-Eastern Railway has many features in common with the car used on the Delaware and Hudson Railways, though as a matter of fact the American autocar on the railway just mentioned is to a large extent a reproduction of the earlier autocars built by the N. E. R.

The latest N. E. R. autocar is illustrated (Fig. 3), and is of the ordinary bogie type. There is accommodation for only one class of passenger; the compartment on the right of the illustration contains an 80 h.-p. four-cylinder horizontal petrol engine by the Wolseley Tool and Motor Company, having cylinders 8½ in. × 10 in. stroke, running at a normal speed of 420 revs. per minute, which however can be increased to 480 in order to accelerate rapidly. The fly-wheel is 3 ft. diameter. All valves and cylinders are water cooled, the cooling water is kept at a low temperature by a "Clarkson" radiator and a "Blackman" fan. It will be noted that the engine is only about half the size of that used on a similar car described in these notes in April; the car then described was larger and designed for somewhat higher speeds. Nevertheless the American car seems, relatively speaking, to be somewhat extravagantly equipped. The engine is governed on the throttle, but an auxiliary hand throttle is provided so that the driver can obtain a temporary increase in speed during acceleration, this hand throttle being manipulated from either end of the car.

Direct connected to the engine is a 55 k.w. multipolar dynamo, compound

* THE ENGINEERING REVIEW, Nov. 1905, April and August, 1906.

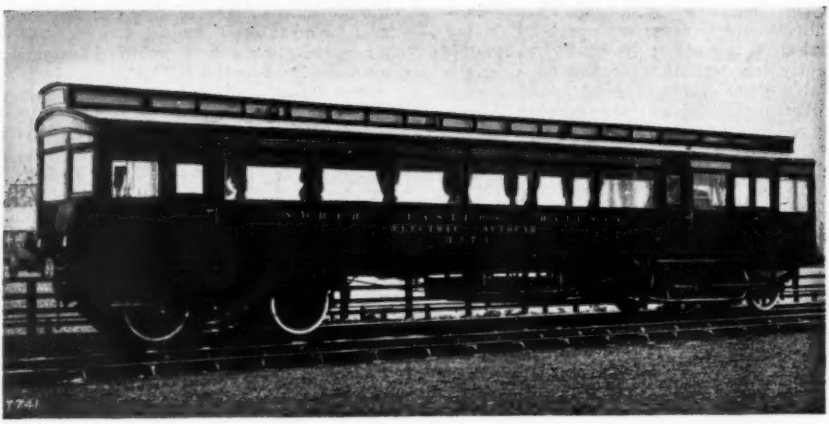


FIG. 3.—PETROL ELECTRIC CAR, NORTH-EASTERN RAILWAY.

wound, but with the shunt field separately excited from a $3\frac{3}{4}$ k.w. exciter which is mounted above the main generator, and driven from it by a belt. This exciter also supplies current for lighting the carriages, which is carried out at a pressure of 72 volts; there is a storage battery of thirty-eight cells for this purpose when the engine is at rest.

The bogie truck under the machinery compartment is equipped with two 55 h.-p. "Westinghouse" traction motors, geared through single reduction spur gear to the axle; these are controlled by ordinary series parallel control. On the other bogie is an electrically driven air compressor for the whistle.

The storage battery already alluded to is used for starting the engine. The car is usually started by the series parallel controller, after the generator pressure has reached 400 volts; when a good speed has been reached the excitation of the generator is increased by means of the shunt regulator to give 550 volts, with a corresponding increase in speed. A maximum speed of 36 miles per hour is attained with a car weighing about 35 tons.

There is accommodation for fifty-two passengers and the car is heated by radiators in winter.

The usual electric braking arrangement found on all tramway equipments is of course part of the controller equipment, but in addition a "Newell" magnetic brake is fitted to each truck.

Metallurgical Progress.

By PERCY LONGMUIR.

FOUNDRY PRACTICE.

Comparative Designs and Working of Air Furnaces.—Air furnaces are by no means adequately treated in foundry literature, and reliable data is very seldom given. For this reason we turn with much interest to a paper presented by Mr. Ralph. H. West to the American Foundrymen's Association.* The matter given, although essentially American, is none the less of high value to British practice. At the outset, the advantages of an air furnace over a cupola are stated as: (1) Lower sulphur in the re-melted product; (2) the opportunity of changing the silicon, manganese, phosphorus, or total carbon contents of the heat whilst it is in the molten state; (3) in giving large bodies of hot metal at one tap; (4) in obtaining a stronger iron from the same brand by virtue of the refining action and freedom from contact of fuel; (5) in the ability to deal with massive scrap which could not be charged into a cupola.

The operation of an air furnace demands more skill than that of a cupola, and special attention should be paid to firing, for unless the metal comes down hot at the start, the temperature can only be raised at the expense of loss of silicon, &c. Owing to air furnaces generally depending on natural draught the state of the atmosphere has an effect on the speed of melting. Again, the same area and height of chimney will not suffice for the same style furnace in all localities. The proximity of high buildings, hills, &c., must be taken into consideration. Fig. 1 illustrates a type of air furnace known as the "Camel back," the bed of which is formed of silica sand varying from 1½ to 6 ins. in thickness. The bed is covered with wood slabs in order to protect it when charging. The coal used is specified to contain less than 1·3 per cent. sulphur, as a rule the content of this element ranges from 0·85 to 1·10 per cent. The melting ratio averages about 3½ lbs. of iron to one of coal. The charges generally consist of old rolls and charcoal pig iron, the time of melting varying from 6¼ to 6¾ hours for a 24,000-lb. charge. Fig. 2 shows a 10-ton air furnace with a straight level top. It was originally 10 ins. higher at the charging end as in keeping with the dotted lines *R.S.* The end at *R* was recently lowered because the flame drew along the top so much that good hot iron could not be obtained. A heat of heavy scrap and pig iron taken from this furnace on April 19th, gave 10½ tons in six hours, at a fuel ratio of about 1 to 4. The iron was not tapped until one hour and thirty minutes after it was all down, and its condition was then "very hot." A 45-ton air furnace is also described, and a heat from it on April 10th gave 35 tons in nine hours, and the fuel worked out to one pound of coal to 3⅝ lbs. of iron. A later heat of 25 tons gave a ratio of 4 to 1, and 45 ton heats have been melted down at a ratio of 5 lbs. of iron to one of coal. Fig. 3 shows a modified type of "Pittsburg" air furnace, the bottom of which is formed of floor sand to a depth of from 6 to 8 ins. A 15-ton charge of half pig and half large scrap was melted down in about seven hours at a fuel ratio of 1 to 3¾. Finally two types of British air furnaces are given, but these do not by any means represent modern British practice in this direction. However, Figs. 1, 2, and 3 are worthy of very careful study by British founders, and especially by those interested in the production of special quality irons, as for cylinders, chill rolls, malleable cast, &c.

* *The Iron Trade Review.*

Fluxes in the Cupola.—Mr. N. W. Shed, in a paper before the American Foundrymen's Association, states that the value of fluxes in the cupola is not generally appreciated by founders. Not only may iron be lost by combination with the cinder, but infusible cinder will also enclose small masses and shots of iron which cannot be separated. Another value of fluxes is found in their cleansing action on the cupola. A well slagged cupola has no hanging masses of iron and cinder which require laborious chipping out. Having stated the value of fluxes the author passes on to a consideration of the two chiefly available, limestone and fluorspar. Concerning the latter, practical tests made by the author have shown it to be an inferior flux, it did not remove sulphur, and the properties of the iron were not improved by its use. Limestone is far cheaper than fluorspar, and is also far better as a flux. The form of the limestone is immaterial so long as it is pure, and it may be marble, soft or hard limestone, oyster or mussel shells. The test of purity lies in silica not exceeding 3 per cent., sulphur below 1 per cent., and lime at least 51 per cent. The amount of limestone to be used is variable, depending on the amount of silica in the coke ash, on the amount of sand adhering to the charge, and on the amount of silica to be carried by the slag. The most

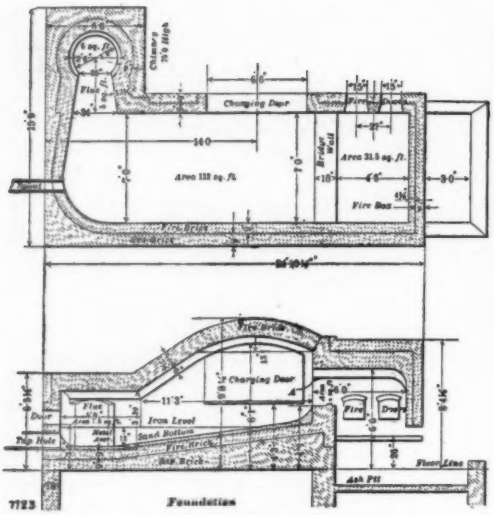


FIG. 1.—CAMEL-BACK AIR FURNACE: 15 TONS.

fusible slag has been found to be a monosilicate which means having equal amounts of silica and alkaline bases. In view of the variables quoted, the author finds a good rule in allowing 25 per cent. limestone on the weight of the coke. This amount will flux any ordinary coke ash with the average amount of sand on pig and scrap. With low coke ash, machine cast pig and clean scrap, the limestone may be reduced to 20 per cent. and still make a good cinder. If more than 30 per cent. is required to make a good cinder and clear the cupola, it is evident that either the coke is very high in ash or else the limestone is high in silica. In the latter case a large amount of lime is used in fluxing its own silica. Analyses of cupola slags where no flux is used show from 14 to 28 per cent. ferrous oxide, with from 2 to 4 per cent. of shot iron mingled with the cinder. This proves that some of the iron must be lost in order to flux the ash of the coke and the sand adhering to the charge. In this respect the following analyses are instructive as showing the types of slags produced when using lime and when working the cupola without it:—

	Using lime.	Without lime.
Lime	34·60	6·60
Ferrous oxide ...	4·10	21·76
Alumina	11·02	11·80
Silica	48·20	58·44
Manganous oxide...	1·40	1·30
Sulphur	0·20	0·10

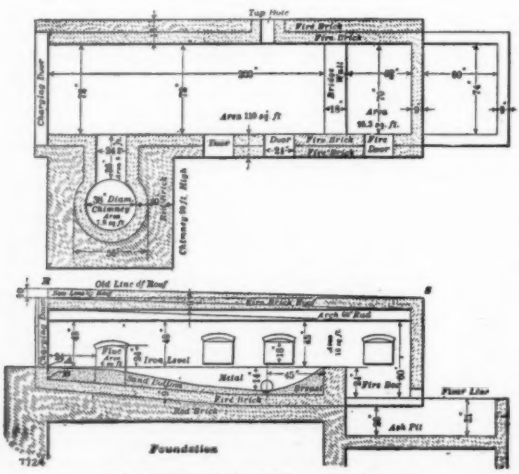


FIG. 2.—AIR FURNACE: CAPACITY, 10 TONS.

Pyrometry in the Foundry.—Mr. Reginald Meekes, writing under this heading in *The Engineering and Mining Journal*, states that whilst the thermo-electric pyrometer has been successfully used in many branches of metallurgy, it has in the case of cast-iron an almost virgin field. Unfortunately the author does not clearly indicate the advantageous use of a thermo-couple in an ordinary iron foundry, but the following paragraph may be taken as giving some index of this application. Used in connection with the pouring ladle the correct temperature for pouring may be quickly and accurately determined. In malleable foundries the annealing of castings is of prime importance, and here accurate temperature knowledge must be of great value. Annealing pits for car wheels could be readily equipped, and core ovens would certainly profit by the intelligent use of a thermo-electric pyrometer.

Modern Pipe Founding.—Mr. H. A. Croxton, in a paper before the American Foundrymen's Association, discusses various aspects of pipe founding. Starting with an outline of the proposed plant, his remarks are based on a pipe foundry with a yearly capacity of 60,000 tons. The plant should be located on not less than 40 acres of ground with buildings centrally situated. The modern pipe foundry handles from 500 to 600 tons of material per day, and such handling must be done at the least possible cost. For this

reason the pig iron yard should be on a level with the cupola stage, and the plant should be laid out on a 1 per cent. grade line down to the finished product track which should be depressed. The writer believes that cupola charges mixed by analysis, without paying any attention to fracture, produce the best results. In his own practice each car-load of iron is analysed and handled accordingly. The coke is also analysed, special attention being paid to the amounts of sulphur and ash. In the author's foundry 3, 4, and 6-in. pipes are moulded three in a box, whilst 8, 10, 12, and 14-in. pipes are moulded two in a box. From 16 ins. to 72 ins. inclusive are cast singly. To ensure central cores tapered socket chill plates with a corresponding taper on the core are used, whilst at the top of the flask a tapered socket core fitting into the tapered mould is used. A central opening in this core ensures the top of the pipe core being located in a central position. All pipe moulds are dried through the night, the author not being in favour of skin drying. After casting, the pipes are allowed to cool for about half an hour, they are then removed from the flasks and permitted to roll into the cleansing department. For chipping compressed air has been tried, but in the author's experience a good chipper with chisel and hand hammer can clean more pipe than the most expert man with a pneumatic hammer. After cleaning, the pipes are run into an oven which is of sufficient length to permit a 72-in. pipe to make one complete revolution in passing through. In making this revolution the pipe has been heated sufficiently to permit of dipping in tar which is effected by means of an electric elevator. After the tar coating has set each pipe is separately weighed and then tested hydrostatically to 350 lbs. per sq. in. Probably the most important feature in the operation of a pipe foundry lies in the ability to establish a first class organisation and in running the plant to its utmost capacity every working day in the year. There is a heavy overhead charge in the making of cast-tron pipe which amounts to about two dollars per ton. A full capacity permits of the absorption of this charge on a satisfactory basis. Depreciation in the case of pipe foundries is heavy, and it is the author's practice to write off 50 cents per ton from the plant each year in addition to allowing 50 cents per ton for repairs. Whilst this may appear excessive, experience shows that it just about covers the exact facts.

The "Baby Bessemer" combined with the "Martin" Process.—In *Giesserei Zeitung*, Dr. H. Wedding gives a clear description of small "Bessemer" Converters, showing that in certain cases a converter of small dimensions can give economical results. However, the most suggestive part of the paper is found in the relation of the small converter to the iron foundry. Thus an iron foundry may have demands for steel castings, and in order not to lose its custom is compelled to instal a small converter; and though the initial outlay may be high the cost of the product is decidedly less than that of crucible steel, a process which various foundries have been compelled to adopt. Once the converter is installed it may be used for the production of high grade cast iron, this in addition to its legitimate function of steel making. Cast irons containing from 2·5 to 3·0 per cent. carbon and from 1 to 2 per cent. silicon have been produced, which in resistance have yielded 30 kg. per sq. mm. To obtain this the charge is blown to the point where silicon and manganese are nearly completely oxidised, and a quantity of molten cast iron is then added. For example, to a 100 kg. charge blown down to 1·0 per cent. carbon and 0·5 per cent. silicon, 100 kgs. of cast iron containing 3·5 per cent. carbon and 2·5 per cent. silicon are added, resulting in a mixture containing 2·2 per cent. carbon and 1·5 per cent. silicon. Although the author does not term this product semi-steel, such a description would be applicable, and judging from the composition comparatively high mechanical properties would follow.

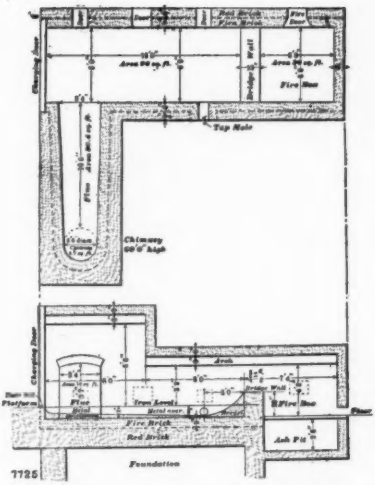


FIG. 3.—MODIFIED "PITTSBURG" TYPE AIR FURNACE: CAPACITY, 15 TONS.

Recent Processes in Machine Moulding Practice.—Mr. Ph. Bonvillain commences with a general survey of machine moulding, leading up to a description of his own machines. The paper submitted to the last meeting of the Iron and Steel Institute is well illustrated and worth a careful perusal. For the present we can only note the leading features of these machines, which the author terms "Universal." The moulding machine

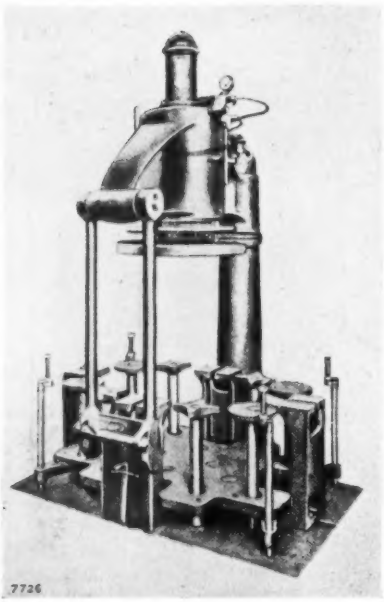


FIG. 4.—VIEW OF G. M. MOULDING MACHINE.

consists mainly of a pedestal frame, the top of which forms a variable hollow table or surface on which is fixed the pattern plate. A movable cross beam pivotted on a back column carries the hydraulic ram to press or ram the sand in the moulding box. At the other end of the cross traverse opposite the column is a movable hook which allows the cross traverse to be fixed in the right position for ramming. This part of the machine constitutes the moulding press. *Parting-off machine.*—Inside and at the bottom of the pedestal is a vertical hydraulic ram carrying a table well guided through the pedestal; this ram is provided in order to force up the finished mould from the pattern plate. For this purpose the table carries four adjustable brackets, holding four vertical rods working outside the pedestal engaging the protruding corners of the moulding box or of the stripping plate. In addition to this, small adjustable columns may be disposed on the table, inside the pedestal, to support the vertical cores, should any be present, by means of small wooden or metallic stools provided through the pattern plate. These small columns and the outside rods having been adjusted, it is easy to see that a mould so supported will be lifted or forced out from the pattern plate immediately pressure is applied to the lifting ram. A double-pressing device is provided by means of which, when the mould and cores have been pressed down, the cores specially receive an up-pressing from below. In order to economise water a telescopic hydraulic ram has been provided and the length may be regulated at will according to the depth of the boxes used. Various sizes of these machines have been designed, and the illustration (Fig. 4) shows one specially intended for the production of large castings.

GENERAL METALLURGY.

A New Occurrence of Vanadium in Peru.—Mr. Foster Hewett gives a preliminary note in *The Engineering and Mining Journal*, on a deposit discovered on November 20th, 1905, in the neighbourhood of Cerro de Pasco, Peru. The physical properties of the material are as follows:—Colour, dark green, about the same as olivenite, cleavage conchoidal to uneven; streak, greenish black; hardness, 3·5; specific gravity, 2·65. The following analysis was made by J. O. Hardy, of Pittsburg:—Moisture, trace; silica, 10·88 per cent.; alumina, 3·85 per cent.; iron, 2·45 per cent.; vanadium, 16·08 per cent.; sulphur, 54·06 per cent.; molybdic oxide, 0·50 per cent.; sulphur (soluble in carbon bi-sulphide), 6·55 per cent.; vanadium and iron are expressed as metals because their exact condition has not been determined. The amount remaining unaccounted for is largely carbonaceous matter. At the time of writing, the only development consists of a few prospecting pits extending along 400 feet of the outcrop, but there is already a large quantity of the material exposed. It is evident that this material is richer in vanadium than any previously known. This feature, taken in conjunction with the large quantity available, appears to assure the commercial future of vanadium, that is provided the experiments of recent years are borne out by practice.

Concerning the Alloying Power of Calcium.—Mr. L. Stockem, in *Metallurgie*, recounts a series of experiments with calcium. The results show that whilst calcium will not serve for refining cast iron it will render good service in the case of copper. In making alloys of copper and calcium, liquid copper is poured on to small pieces of calcium placed in a magnesia-lined crucible which has been previously heated. Calcium renders copper fragile, thus bars of 5 cm. thickness containing 7 per cent. calcium broke with a light blow of the hammer. At 20 per cent. calcium the alloy is white, and breaks or disintegrates in air. Experiments have shown that calcium in traces can be used for the deoxidation of copper and can then replace phosphoric copper with advantage. An alloy of aluminium and zinc deoxidised with calcium gave encouraging results.

STEEL: ITS PROPERTIES AND TREATMENT.

Formation of Pipes in Steel Ingots.—Writing in *Stahl und Eisen* Mr. J. Riemer gives the various causes to which piping may be attributed. Turning to a study of prevention, the "Whitworth" and "Harmet" processes are examined and their various features noted. On the whole the author finds that in the "Whitworth" system pressure from the top retards the escape of gases, a disadvantage not present in the "Harmet" system. The latter system is costly in installation and upkeep, and it is a question whether the decrease in crop ends is altogether a gain. Methods of regulating the cooling have long been familiar, the object in this case being to keep the upper part of the ingot hot in order that it shall supply the shrinkage below. In this respect the early work of Ellis, that of the Bochumer Verein and Krupp's practice of covering the tops of ingots with molten slag are mentioned. The author's process of heating by gas and air was fully noted some time ago, and it will be remembered that the upper part of the ingot is arranged to solidify last, thus giving uniform feeding which practically eliminates deep seated piping. The plan has been followed for some time and excellent results have been obtained. The tops of the ingots present a curved surface under which the segregates of phosphorus and sulphur collect. Fully 90 per cent. of each ingot is used, and the works using the process have had no complaint as to quality. From a large number of tests taken from the ingots no greater difference than 2 kgs. for resistance, or 2 per cent. in elongation, has yet been detected between the upper and the lower portions.

Examples drawn from Practical Metallography.—This paper* summarises many aspects of Professor Heyn's researches, but for the moment we note only the following features:—It is recognised that brittleness in mild steels may be due to treatment or composition. That due to treatment can, in most cases, be removed by annealing at 900° C. As a test for brittleness the notched bending bar is advised, and owing to their small section several bars may be taken at different planes from a boiler plate, thus giving an index of the condition of the exterior and interior of the plate. Fragility due to sources outside that of treatment is in most cases due to the liquidation of phosphorus and sulphur. In order to detect these segregates the author advises etching for a period of one minute with ammoniacal chloride of copper. By this treatment the parts rich in phosphorus take a bronze black tint. A simple and ready means of detecting sulphide globules is found in laying over the steel a piece of silk which has been brushed over with a solution of chloride of mercury. On wetting with hydrochloric acid a black stain in the silk indicates the locality of sulphide areas.

* *Stahl und Eisen.*

Experiments on the Segregation of Steel Ingots in its relation to Plate Specifications.—Mr. C. L. Huston, in a paper read before the American Society for Testing Materials, shows that the assumption of uniformity in the properties of rolled steel plate is not always founded on fact. One of the sources of variation is said to lie in the segregation of carbon in the ingot, and many analyses and tests are given in support of this. As an example the following tests are given, and the variations in carbon and tensile strength will be noted.

The Electro-thermal Metallurgy of Iron.*—Major E. Stassano, after a general introduction, gives the following essentials as necessary in order to utilise the heat produced by transformation of electric into thermal energy under industrial metallurgical conditions:—

(1) That the enclosure in which the transformation of electric energy into heat is carried

* Sixth Congress of Applied Chemistry, Rome, and *The Electrician*, Sept. 7th, 1906.

VARIATION OF TENSILE STRENGTH AND CARBON CONTENTS IN PLATE ROLLED FROM SLABS.

	TS 61,440	58,460	58,940	58,260	57,580	58,080	59,240	60,060	
Top.	·17 C.	·15 C.	·15 C.	·16 C.	·16 C.	·16 C.	·15 C.	·16 C.	50,760 ·16 C.
	71,100 ·27	66,940 ·24	66,100 ·23	65,500 ·21	65,300 ·19	63,400 ·19	61,900 ·19	60,840 ·18	60,700 ·15
	77,250 ·38	68,200 ·24	65,940 ·22	66,300 ·22	65,100 ·21	63,400 ·21	62,100 ·17	60,320 ·17	58,850 ·15
	739,00 ·25	68,020 ·20	65,900 ·23	65,860 ·23	64,940 ·22	68,300 ·20	61,740 ·15	61,000 ·17	59,340
	59,700	58,800	58,240	59,100	57,800	58,380	59,300	59,540	·16
	·13 C.	·15 C.	·16 C.	·16 C.	·15 C.	·15 C.	·15 C.	·16 C.	59,540 TS ·16 C.

Bottom.

Ingot, 30 × 34 ins.; weight, 17,600 lbs.; ladle test, 0·19 per cent. carbon; rolled 3½ ins. thick by 29 ins. wide and cut into eight slabs 67 ins. long. Slabs rolled into ¾-in. plate. Five longitudinal test-pieces were taken from the top end of each plate, and a ninth set of five from the bottom of the lowest plate, thus giving five tests each at top and bottom and at seven intermediate sections. At each section the test-pieces were spaced equi-distant across the plate.

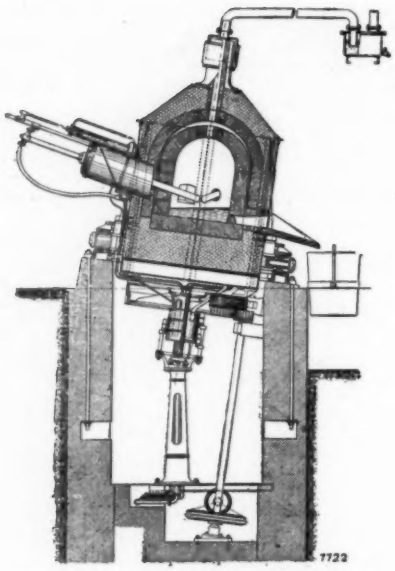


FIG. 5.—VERTICAL SECTION OF THE "STASSANO" ROTATING FURNACE.

out, and also the metallurgical operations necessitating this heat, should be protected from the direct action of the atmosphere and constructed of materials chemically inert.

(2) That the heat developed by transformation should be produced at as high a temperature as possible.

(3) That the materials under treatment should not come into direct contact with bodies susceptible of modifying their composition in a harmful manner.

(4) The apparatus should permit of continuous working with a full charge. Following this the author gives a description of his rotating furnace, the details of which are well shown in the appended illustration. Turning to results, the first quoted are taken from some trials in 1901, at which Dr. Goldschmidt was present, and the following represent his figures :—

Analysis of Ore Treated.	Per Cent.	Analysis of Product obtained by a single Operation.	Per Cent.
Ferric oxide ...	93·020	Iron	99·764
Manganous oxide	0·169	Manganese ...	0·092
Silica	3·790	Silicon	trace.
Sulphur	0·058	Sulphur	0·052
Phosphorus ...	0·056	Phosphorus ...	0·009
Lime & magnesia	0·500	Carbon	0·090
Water	1·720		

This represents malleable iron produced in one operation, In order to effect the reduction the electric energy required amounted to about 5 h.-p. hours per kilogramme of metal produced, which is equivalent to an efficiency of about 60 per cent. of the electric energy used. After these trials a rotating furnace was installed in the artillery works at Turin for the production of steel used in the manufacture of projectiles. From certificates given by the War Office referring to 38 successive operations, it follows :—

(1) That the furnace produced in ordinary working 2,500 kgs. of steel per day, in refining pig iron and smelting scrap with a loss not exceeding 20 per cent., although the charge included 75 per cent. of turnings.

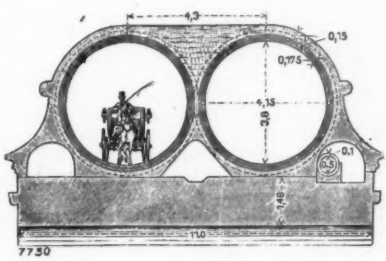
(2) That a charge of 600 kgs. included at least 150 kgs. of pig iron, for the refining of which 29 kgs. of iron ore and 6 kgs. of lime are required.

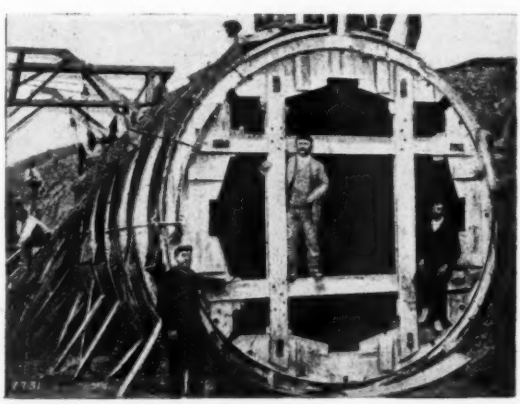
(3) That each operation requires the expenditure of 850 k.w. hours of electric energy.

Engineering Progress.

Loading Tests on "Visintini" Girders.*—To test the strength of "Visintini" girders, intended for a road bridge over the railway at the new Copenhagen station, an ordinary pair of these girders, held together in the usual manner by cement mortar and transverse irons disposed in the dovetail recesses in the side of the girders, was covered with 4 ins. of ferro-concrete and loaded in such a manner as to apply the whole of the direct strain to the one girder, up to breaking point, in order to see how far the second girder would be affected. To apply the load, a pair of turntable girders was arranged over the girders, so as to support the latter by means of slings. A hydraulic jack was then mounted on the centre of the girder to be tested, so as to abut against the turntable girder, and pressure applied by this means. The working strain which the girders were calculated to stand was equivalent to 11.1 tons applied by the press; and the tests showed that up to a load of 24 tons the deflection was practically uniform and disappeared almost completely on the removal of the pressure. The first visible cracks occurred at 45 tons, and demonstrated the satisfactory character of the connection, the cracks extending from the foot of the loaded girder into the foot of its fellow, although the sole connection was along the head. At about 65 tons the maximum carrying power of the girder was attained, since they yielded under this pressure on the press pumps being started again; but as they continued to bear about 90 per cent. of full load after breaking point was reached, there seems little risk of this class of girder buckling and collapsing suddenly.

Ferro-Concrete Irrigation Syphon at Sosa (Spain).†—In the construction of the canal for irrigating a large area of the Arragon plateau, it was found necessary to employ a syphon in order to carry the water across the valley of the Sosa river; and for this purpose the construction of a double ferro-concrete main was decided upon, the cost (1½ million pesetas) being only half the estimate for iron mains. The project was devised by Sr. J. E. Ribera, and is unique, the twin mains measuring 12 ft. 6 ins. in diameter, with a total length of 3,340 ft., and a total head of 88 ft. 6 in., thus eclipsing the 10 ft. 10 ins. ferro-concrete main at Champs (Isère). The mains are partly laid in the ground, and partly on the surface, covered with an embankment of earth, whilst an aqueduct 590 ft. long carries them over the river. This aqueduct consists of concrete arches 36 ft. wide and 49 ft. span, and is shown, as a section, in the illustration.





FERRO-CONCRETE IRRIGATION SYPHON.

* S. M. Andersen. *De Ingenioren.*
† *Beton und Eisen.*

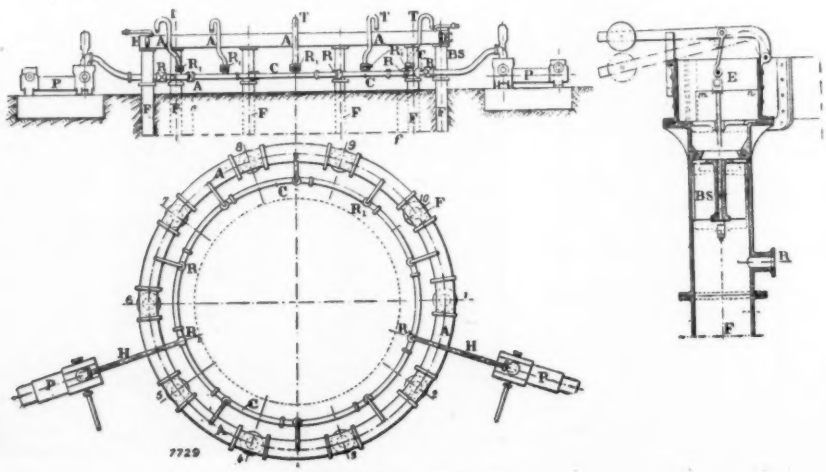
The mains are constructed of ⅛ in. sheet iron, the individual plates, 10 ft. by 4 ft. 6 ins., being riveted by hand into tubular form, the original idea of welding them having proved impracticable in the circumstances. These pipes are lined with ¾ in. of cement, and are strengthened by peripheral and axial T-irons, embedded in 6 ins. of concrete, so that the total thickness of the mains is 6⅞ ins. They are laid on a bed of ordinary concrete, the load being distributed in such a manner as to prevent settlement in any part. The pipes were built up in sections about 21 ft. long, on the spot, rolled down a gentle slope into position, the cement lining being then put in and the joints strengthened with collars. The work was completed in five months.

Apparatus for Sinking Pits by the Cementing Process.—M. Leon Saclier, chief engineer at the Anzin colliery, has devised a form of apparatus* for use in the sinking of pits by the cementing process, in which liquid cement is forced under pressure into the fissures of water-bearing strata, in order to keep back the water from entering the shaft in course of sinking. A number of boreholes *F* are driven around the site of the pit, as far as the water-bearing strata, and lined with casing. At the head of each casing is attached a valve chest *B S*, and these in turn are surmounted by troughs *E*, supporting the valve levers and fitted with diaphragms *m n*, the troughs and connections *A*, forming a circle round the pit. Each valve chest is also in communication with a circular pipe *C*, by means of pipes and taps *R*, and the circular pipe is connected with the pumps *P*, as also with the connections *A*, by pipes and taps R_1, and swan neck pipes *T*.

The working of the apparatus is as follows: To ascertain whether fissures extend, for instance, between the opposite boreholes 1 and 6, the valve chests of each are connected to the circular pipe leading to the pumps, the tap *R* at the No. 1 hole being opened and the valve closed, while the converse is effected at No. 6 hole. The pump then forces water down the No. 1 hole, and if there is any connection between them, the water rises in the No. 6 hole. When the fissures have been located, the taps *R* are closed, and those marked R_1 are opened, the pumps being set going and forcing water into the troughs *E*, whence it descends over *m n* and through the valves into the boreholes. Cement is mixed with this water, and the resulting cement milk enters the boreholes at low pressure. To increase the pressure, so as to force the cement into the fissures, the taps R_1, and the valves are closed suddenly, and the taps *R* opened, the speed of the pumps being increased at the same time. This operation is repeated until the back pressure on the pumps indicates that the cement has closed up the fissures.

Another system has been devised by a

* H Schmerber. *Le Génie Civil.*



APPARATUS FOR SINKING PITS.

French mine manager, M. Duvivier, for use in the case of vertical fissures. When the pit has reached the water-bearing strata and has been tubed, a bottom ring of tubing, with a number of outwardly projecting pipes, is put in, and the shaft is closed by a false bottom. The water under this latter having been pumped out, cement is poured in until the space underneath is filled, and when this cement has set, inclined boreholes are driven through the sloping pipes, each borehole being injected with thin cement until the fissures are choked up.

Lining a Colliery Shaft with Ferro-Concrete.*—A new departure in colliery practice has been made at the Wilhelm shaft at the Koenig (State) Colliery, in the Saar district of Germany, by the substitution of ferro-concrete for the old wooden lining over a depth of about 470 ft. The ferro-concrete plates are 9½ in. thick and are backed with rammed concrete, the plates on the longer sides of the rectangular shaft being strengthened by two 6 in. ribs. The iron rods, ⅝ in. in diameter, are inserted horizontally in the concrete, 4 ins. apart, or closer together in the places where pressure is anticipated, whilst 24 rods are disposed at regular intervals all round the shaft. The corners are strengthened with angle irons, 2 by 2 ins. In the cross walls for supporting the cage guides, the horizontal and vertical rods are arranged in pairs at intervals of 11 ins., and fastened together to form a skeleton. The guides are carried on H-girders, riveted to iron plates 12 by 6 by ½ in., which in turn are bolted to the guides. The concrete is compounded of one part Portland cement, 2½ of broken diorite and 1½ of sifted sand, and is firmed by ramming.

The Flow of Hot Water through a Nozzle.†—The observations recorded by the author in the course of an exhaustive paper are summarised as follows: During the efflux of highly heated liquids, the transition from the internal to the external pressure does not proceed in the ordinary manner, namely, that the pressure at any moment corresponds with the saturation temperature, but extensive superheating phenomena occur. This explains the larger volume of water discharged than could escape under ordinary evaporation. The evaporation, and thereby the volume discharged, are both largely influenced by the character of the nozzle (rough or smooth) in the bore. The external pressure will be attained only when evased nozzles are used; and if the nozzle be widened sufficiently an effect of suction will be set up in parts of the nozzle owing to the pressure in the latter falling below that of the outer air.

A New Arc Lamp.—The accompanying illustrations refer to a new and interesting design of arc lamp, the principal feature of which is its extreme simplicity. Shunt coils, wheels, sliding rods, dashpots, brakes, and such like mechanism have been eliminated and only one moving part substituted, with the result that the makers claim to be able to place a complete lamp on the market at a very low price. Moreover, by reason of the simplicity of the design, it is claimed that the cost of repairs and maintenance is reduced to a minimum.

The details of the construction will be readily followed by the aid of the photographic reproductions, of which Fig. 1 is a view of the lamp complete, Fig. 2 the lamp with the case, globe, and shade removed, and Fig. 3 the sleeve clutch.

The primary objects of the designers have been to dispense with holders connected to the current supply on the upper carbon, thus to obviate the possibility of burning the holders, and further, to facilitate the employment of an upper carbon exceeding in length those hitherto used in other lamps.

These objects have been attained in the

FIG. 1.—THE "VICTOR" ARC LAMP COMPLETE.

* Hundt. *Zeitschrift für Berg.* Hüllen-u-Salinenwesen.

† J. Adam: *Zeitschrift des Vereines Deutscher Ingenieure.*

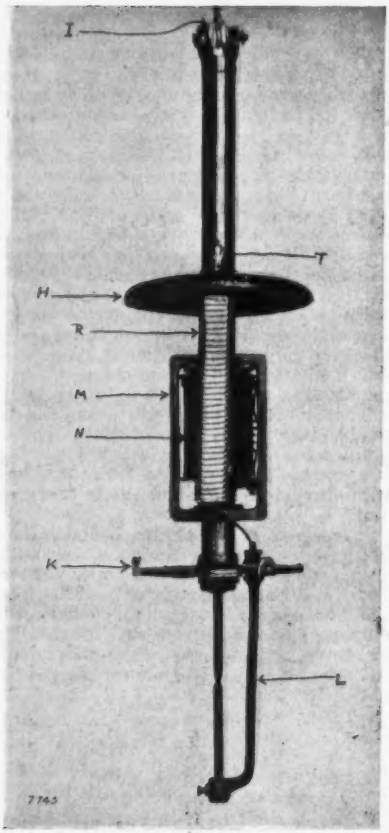


FIG. 2.—THE "VICTOR" ARC LAMP, SHOWING THE CASE, GLOBE, AND SHADE REMOVED.

following manner. Referring to Fig. 3 the positive carbon *C* passes through the sleeve clutch *D*, provided with flanges *G*, which are in electrical contact with the positive lead. The sleeve is provided with a soft-iron armature *A* and a movable armature *B*, the latter being pivotted at the fulcrum *F*, and operates a grip block *E*. The sleeve clutch is carried in a tube integral with the base *K* shown in Fig. 1, surrounding which is a solenoid or series coil *N* and a soft-iron magnet frame *M*, to the bottom of which is secured a flanged soft cylinder forming the core and pole face of the solenoid *N*.

The latter is in series with the positive lead, the current passing from this lead through the coils, lamp structure, thence through the sleeve to the upper carbon.

The negative carbon holder *L* is connected to the negative lead by the nuts shown.

As soon as current is switched on the solenoid *N* is energised and the armature *B* is attracted outwards, thus drawing the grip block inwards, causing the carbon to be pressed against the opposite side of the bore of the sleeve and to be held firmly. Further outward movement of the armature being in this way arrested, it is pulled upwards, carrying with it the sleeve and carbon, thus striking the arc. On the arc lengthening the grip is relaxed and the carbon consequently feeds.

The upper carbon can be withdrawn from the lamp for inspection by removing a plug screwed into the base of the tube in which

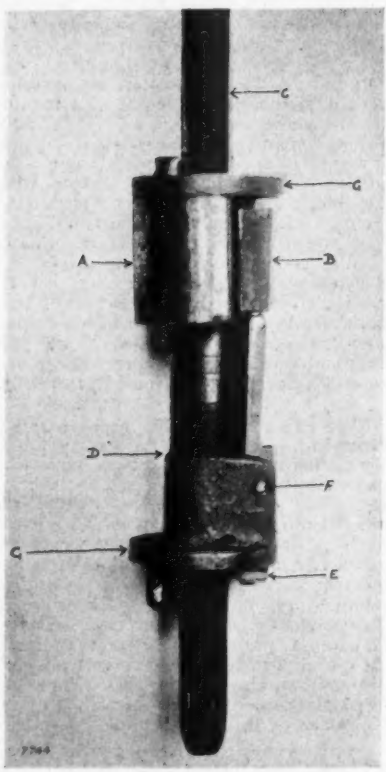
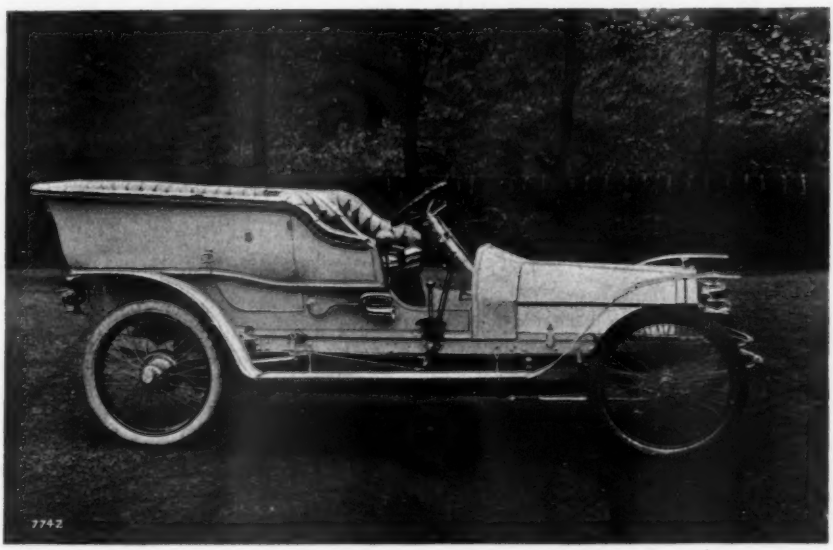


FIG. 3.—VIEW OF THE SLEEVE CLUTCH.

the sleeve slides. This upper carbon may, however, be inserted without removing the plug by simply pushing the carbon up through the plug and sleeve, the lower carbon holder being perfectly insulated from the base *K*, and is hinged to facilitate the placing of the upper carbon in position.

To prevent waste the bottom carbon is of such length as to be entirely consumed by the time the upper carbon has been burnt clear of the sleeve and is resting in the plug. The remaining portion of the upper carbon is then of such length as to be suitable for use in the lower carbon holder.

The lamp, which can be arranged as either an "open" or "closed" type, is stated to possess an efficiency equal to that of any high-class arc lamp on the market, and it burns with a remarkable absence of "pumping."



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BOOK REVIEW.

Polyphase Currents. By ALFRED STILL, A.M.I.C.E., M.I.E.E. (London: Whittaker) Price, 6*s.* net.

The work under review represents an effort to meet the demand for an easily understood survey of the general phenomena of alternating currents. The author has covered the entire field as well as can be expected within the limits of 340 pages. Starting out with the elementary principles of alternating currents, he proceeds to deal in a lucid manner with the phenomena of self-induction and capacity, passing then to generators, the calculation of power, transformers, phase transformation, and general power distribution. The concluding portion deals with such power-consuming and transforming devices as induction and synchronous motors, rotatory converters, and the like.

By adopting graphical treatment of the phenomena with which he deals, the author has made his work available to a wider circle than he might have done had he followed the mathematical efforts of most writers. Kelvin's law for determining the most economical section of a cable is well and clearly expounded; indeed, the laws of electric power transmission have received a considerable share of the author's attention, and very properly so, for the subject is not so well known as one would expect, economical transmission not having hitherto received the attention which it deserves.

The author has done his work well, and added a really good book to the literature on the subject.

CATALOGUES.

American Locomotive Co., New York. Descriptive pamphlet of "Atlantic" type passenger locomotive built by the company.

W. & T. Avery, Ltd., Birmingham. Sheets No. 222 and 223 dealing with a patent impact testing machine and a combined testing machine for cast iron. Also sectional catalogue of testing machinery.

Cambridge Scientific Instrument Co., Ltd., Cambridge. List No. 39, on technical thermometry. It is divided into three sections: (1) Dealing with the more particular commercial applications of pyrometers; (2) scientific and research work; (3) an appendix explaining the theoretical considerations of the instruments and giving tables of general interest. Amongst the latter, attention may be drawn to the table of melting points obtained by Dr. Harker of the National Physical Laboratory. These values will be found to differ very materially from those generally accepted in textbooks.

An interesting application of electrical thermometers is that of measuring the temperature in cold stores. In the past the tedious method of sending a man round to read a mercury thermometer fixed in every chamber was adopted, but now it is possible by means of electrical thermometers for the engineer to read the temperatures throughout a large building from the engine room. In the case of one large cold stores the time saved in reading the thermometers by the method described amounts to no less than six hours a day.

The Coil Clutch Co., Phœnix Works, Johnstone. Illustrated catalogue of the latest type of coil friction clutches manufactured by this firm. Type 1 is described as a shockless elastic coil clutch, and has been specially designed to couple gas engines or electric motors to heavy machinery, particularly such as is subject to sudden shocks or jars such as occur in rolling mills, pumps, compressors, crushing machinery, &c. The absorption of shocks is effected by means of buffer springs fitted into the face of the driving plate against which the coil drives. For high speeds the starting levers are arranged so as to tighten the coil gradually and to set up the required frictional contact in sections which, it is claimed, accomplishes a slipping and shockless start at the highest speeds. Amongst the extensive applications of apparatus arranged on the coil clutch principle, described and illustrated in the list, is one arranged to reverse rolling mills. In this case the gearing is arranged to start the rolls at a reduced speed and then transmit the full speed and power when the rolls have taken the ingot or bloom, an arrangement for which the makers claim a large and economical advantage.

John Gibbs & Son, 72–76, Duke Street, Liverpool. Leaflet illustrating and describing a ventilating and dust collecting plant for polishing and grinding shops. By this apparatus the dust is removed direct from the polishing bobs before it has had time to spread about the room and is collected. In the case of wood-working machinery and mills where the produce is saleable, the apparatus is of particular value.

Simplex Conduits, Ltd., 11, Queen Victoria Street, E.C. Leaflet No. 162 dealing with three additions to the "Simplex" system, viz., a new pattern lampholder for use in damp situations; a ceiling rose specially adapted for mill and factory lighting, and, finally, a wall-fastener which dispenses with the necessity of plugging.

Also Leaflet No. 161 which deals with new "Simplex" flush mounting boxes. These are quite a novel departure in methods of mounting switches and other forms of electric lighting fixtures, and as they are intended for concealed work, special attention has been paid in their design to reducing the depth dimension, thus minimising the channelling out of brickwork during erection.

James Archdale & Co., Ltd., Birmingham. Ninth Edition, 1906. Catalogue of machine tools.

Sanders, Rehders & Co., 108, Fenchurch Street, E.C. Third Edition of booklet describing the "Sarco" Automatic CO_2 Recorder.

R. Waygood & Co., Ltd., Falmouth Road, Great Dover Street, E.C. Pamphlets dealing with (1) the relative merits of electric and hydraulic power in the working of lifts and cranes; (2) cliff lifts with special reference to the two at Bournemouth; (3) list of firms and garage owners where "Waygood" motor car lifts have been fitted.

J. G. Wagstaff, Ltd., Dukinfield. Catalogue of hot water boilers.

Clarke, Chapman & Co., Ltd., Gateshead. New Edition of catalogue of latest designs of direct-acting steam pumps (Woodeson's Patent).

W. H. Bailey & Co., Ltd., Salford. Descriptive illustrated pamphlet of the "Aqua-Thruster" steam pump.

John Spencer, Ltd., Wednesbury. Catalogue of tubes and fittings for gas, steam, water, &c,

Crompton & Co., Ltd., Salisbury House, London Wall, E.C. List D. 28, dealing with small motors for continuous current circuits.

Babcock & Wilcox, Oriel House, Farringdon Street, E.C. Booklet giving a description and dealing with the performances of this firm's mechanical chain grate stoker for burning bituminous coal smokelessly.

NOTES.

High-Pressure Joints.—Messrs. Newton and Nicholson, of The Tyne Dock Corrugated Metal Packing Works, South Shields, submit a sample of their patent packing for steam or other joints, designed more particularly to withstand very high pressures, but it is claimed to be applicable to any form of flange joint or any pressure. The principal features of this novelty, which may be briefly described as consisting of a thin sheet of corrugated metal of any desired shape to suit the faces of joints, are simplicity combined with very high efficiency.

The corrugations are usually of ¼ in. pitch, rectangular ΛΛΛ-shaped, the ridge and base angles being always retained in continuous line, the distance from the base to the apex of each corrugation is therefore ⅛ in., which constitutes the thickness of the joints.

It will readily be seen that a sheet of metal formed as described with the cavities on either face filled, or partially filled, with some plastic mixture, must produce a very secure joint indeed, the corrugations being formed transversely to the direction of the pressure, a perfect barrier is maintained, and the chances of "blowing out" thus reduced to a minimum.

Messrs. Newton and Nicholson manufacture under their patent, packings of any shape and for any size of joint.

The Pulsometer Engineering Co., Ltd., of Reading, have recently opened offices in Manchester, at 206, Corn Exchange Buildings, Cathedral Street, with Mr. George Thompson as manager, and their agency with Messrs. F. B. Welch & Co. is therefore terminated.

"Meldrum" Furnaces for twelve stationary boilers have just been ordered out for the San Paulo Railway Company of Brazil. The company had four boilers equipped with these furnaces eight years ago, and the success of these has led to the remaining boilers being fitted.

Meldrum Bros., Ltd., are also executing repeat orders for their furnaces and stokers for the Midland and North Eastern Companies.

File Testing.—With reference to the subject of file testing which has excited so much interest recently, the necessity for an adequate test is recognised by the India and War Offices, and Messrs. Edward G. Herbert, Ltd., of Manchester, have received an order for one of their patent automatic file testing and indicating machines from both departments.

Several Sheffield makers of files are putting machines down to test their products, and it is anticipated that considerable improvements in files will be effected.

When makers are able to show definitely what their files will do, efficiency and not cheapness will rule the market, and really good files will be able to command their price.

"Fastnut" washers, we are advised, are now being supplied to the Admiralty and War Office, and orders have been received from several of the leading English Railway Companies, about twenty Borough Corporations as well as Tramway Companies, and many of the largest engineering firms. That "Fastnut" is also moving abroad is proved by the last letter received from the firm's Indian representative, who states "he has received orders from six Indian railways, with a repeat order for 100 gross from one of them."

The "Kennicott" Water Softener Company, of 29, Great St. Helens, E.C., inform us that they have received advices of an order having been sent from the Madras Railway and also announce the sale of "Kennicott" water softeners and purifiers to the Finchley Urban District Council and to the Cheltenham Borough Council for their electricity works. The former is of a capacity of 25,000 lbs. per hour, and the latter of 30,000 lbs. per hour.

Messrs. Geo. Richards & Co., Ltd., Broadheath.—At a recent meeting of the directors of Messrs. George Richards & Co., Ltd., and Tilghman's Patent Sand Blast Co., Ltd., Mr. Alfred E. Matthewson was elected to the vacancy on the board caused by the death of the late Mr. J. E. Matthewson. The appointment carries with it the active management of the undertakings of the two companies, which was in the hands of the late Mr. Matthewson for a long period. Mr. A. E. Matthewson, who thus succeeds to the responsible position for so long held by his father, acted for more than ten years in the capacity of assistant manager, and he has therefore a complete knowledge of the important interests entrusted to him.